CHARLES FRANCIS BRUSH.

CHARLES FRANCIS BRUSH, M.E., Ph.D., Electrical Engineer, Cleveland. It has become almost a trite saying that the mental as well as the physical strength and power of a country is most likely to proceed from the farm; and it was amid the healthful, rural scenes of Euclid Township, in the invigorating Lake Erie air, that Charles F. Brush was born, March 17, 1849, and grew to energetic boyhood. His parents were of old Eastern stock, and they gave their son a goodly bodily and mental heritage for his start in the battle of life. The early days of Brush were spent on the farm, after which he entered the public schools, his parents taking particular advantage of the excellent school system at Cleveland, where much better opportunities were afforded than nearer his home. While quite young the natural bent of the mind of the future inventor began to manifest itself, and he devised experiments at home and at school that indicated his special taste for chemistry, physics, and engineering. In chemistry and natural philosophy, as indeed in his other studies at school, young Brush was very proficient. In 1862, while aged but thirteen years, he made his first experiments with magnets and batteries, and while at the high school, in 1864, he became much interested in the subject of microscopes and telescopes, making a number of them for himself and his companions. He constructed every part of these instruments, even to grinding the lenses. In the same year he devised a plan for turning gas on the street lamps, lighting it, and then turning it off again, by electricity. He also constructed a number of induction coils, and greatly amused himself and his schoolmates by experiments with them. Throughout his school days he was thus constantly working at one thing or another of a constructive character, and some of the inventions in electric lighting, which he afterward so fully developed, were the outgrowth of his early cogitations and experiments. Many of the associates of Mr. Brush's schoolboy days remember interesting anecdotes of the youth at that period, and delight to recall them, now that their old comrade has become so widely known. Having graduated in a four years' course at the Cleveland High School in two and one-half years, and continuing to show a fondness for physics and other studies of a similar nature, Mr. Brush entered the University of Michigan at Ann Arbor, where he took up a course of study particularly suited to his tastes, and by diligent attention to his tasks he graduated as a Mining Engineer in 1869, being one year in advance of his class. Returning to Cleveland from college, he organized a laboratory and conducted the business of an analytical chemist for about three year, becoming noted for the accuracy of his work and the skill displayed in his manipulations. Immediately after this he engaged in the iron business, in which he remained four years. He was married October 6, 1875, to Miss Mary E. Morris, of Cleveland.

In 1875 the attention of Mr. Brush was especially called to the subject of electric lighting, by experiments tried in Paris and London, and in a conversation with Mr. George W. Stockly, vice-president of the Telegraph Supply Company, the question came up as to whether there was not a demand for a dynamo machine of an entirely different construction and superior to the Gramme and Siemens machines, the best then known. Since the times of Volta and Faraday, the problem of using electricity as a cheap and practical illuminator had engaged the attention of the best inventive talent in the world. Although many steps in the right direction were taken, the results that were demanded seemed as far distant as ever, until many of those best posted gave up, and declared success to be impossible. Two things had to be invented. First, a dynamo machine that could generate the proper amount and kind of electrical current for operating a number of lamps in a single circuit. Second, a lamp that could successfully work upon a circuit with a large number of other lamps, so that all would burn uniformly. These two things must be produced, and simplified to such a degree as to make electric light cheaper than large quantities of any other artificial illuminant. As a result of the conversation with Mr. Stockly, it was arranged that Mr. Brush should be afforded any facilities that he might need in the factory of the company at Cleveland, and if he produced such a machine as was required, the Telegraph Supply Company would undertake its manufacture and introduction. Mr. Brush departed without making any pledges, and constructed his machine in private, at his leisure. It is quite probable that he had already pretty thoroughly worked out the problem in his mind. In less than two months from the time mentioned Mr. Brush brought his machine to the factory on Champlain Street. It was set up in the shop, connected by wires to an old clockwork electric lamp with carbon points, and by a belt with the main shaft. The brushes were adjusted, the armature revolved, the current of electricity was generated, and the lamp gave forth its brilliant light. It was a complete and gratifying success. So perfect and complete was this first machine that it has never been out of order since, and is to-day, in 1884, a prac-

tical working machine in regular use. Of course many mechanical and a few electrical changes in Brush machines have since been made, and the immense sixty-five light machine of the present, absorbing forty-five horse power, is not to be compared with the infant of three hundred candle power. But the invention was substantially completed and embodied in this first essay, and has not been departed from materially since.

The machine having been obtained, now for the lamp! Mr. Brush and the Supply Company hunted the country over, hoping possibly to secure a lamp that would be suitable, but none could be found. Mr. Brush believed that he could make a satisfactory commercial lamp as well as a practical machine, and he proceeded to his second task. This was accomplished within a few weeks. The lamp proved to be an invention almost equal to the machine itself, and as at present constructed it is substantially the same in form and principle as the one first produced. Within a year of their commencement both machine and lamp were in working order and ready to be put upon the market. At

O. F. Brush

this time Mr. Brush was less than twenty-eight years of age, but had achieved the beginning of the great success that the world now appreciates and enjoys. In the winter of 1876-77 an arrangement was entered into between Mr. Brush and the Telegraph Supply Company, by which the latter obtained the sole and exclusive right to manufacture and sell under all of the patents of the former, present and future, in the line of electric lighting, subject to a certain royalty. The company was then employing about twenty-five men, and the annual sales up to 1879 were about fifty thousand dollars. In 1880 the name was changed to that of the Brush Electric Company, so as to describe the business in which it was then engaged, the new line of manufacture having entirely superseded the old.

In 1880 the factory was totally destroyed by fire. The company then purchased six acres of land near the Cleveland and Pittsburg Railroad track, north of Euclid Avenue, which they have nearly covered with buildings. The capital stock of the company is fixed at three million dollars, which is less than three-fourths of the value of its property. The capital now invested in the electrical business as an outcome of the Brush light and its accessories is estimated at over twenty-five million dollars, and the amount is growing larger every day. The most prominent of the inventions of Mr. Brush, manufactured by the Brush Electric Company, are the dynamo-electric machines, electric lamps, automatic current governors, carbons, batteries for the storage of electricity, apparatus for electro-plating, apparatus for producing power from electricity, etc. Mr. Brush's foreign patents were sold for a very large sum to the Anglo-American Brush Electric Light Corporation, Limited, of London, England. This corporation has a capital of four million dollars, and is manufacturing Mr. Brush's inventions on a very large scale in London. Mr. Brush possesses an accurate and available scientific knowledge unsurpassed by that of any inventor. He is a fine mechanic, self-taught,

and able to do any work in the shop in a manner equal to the best trained men. He is intensely practical, never sanguine, with no disposition to overestimate his work, and is an excellent business man in the management of his own affairs. So well are his keen judgment and trained skill appreciated throughout the Brush manufacturing establishment, that if any one connected with it has really hit upon some clever expedient for advancing work or improving results, it is with a feeling almost akin to fear that it is submitted to Mr. Brush's quick glance and unerring judgment, for if there be a flaw it is at once detected. If an exceedingly delicate or accurate piece of work is to be done for the first time he will probably do it with his own hands, in his laboratory. He usually spends from ten o'clock A. M. to five P. M. in his sanctum, busily engaged in one of his numerous undertakings or investigations. With the whole resources of a large manufacturing establishment, filled with the most costly and convenient machinery at his command, he probably has the best facilities for experiment and demonstration of any living inventor in the electrical field. A peculiarity of Mr. Brush's methods of work early developed itself. He never made any merely empirical experiments, and in fact be has made comparatively few of any kind, if the word experiment is considered in its strict sense. It is always his habit to find out definitely before commencing work on an invention whether there is practical utility in it, and if not, he does not spend an hour upon it. When his attention is called to a particular subject by the necessity for more improved methods and machines, it is not his custom to look up text books and reference volumes to ascertain what others have done, so as to endeavor to improve on their work, but he aims, if possible, to carve out a new road, avoiding those that have been traveled. After having selected the most approved method, and subjected it to the keenest mental scrutiny, Mr. Brush's next step is usually the preparing, not of a hasty sketch, but of a complete working drawing with full details to scale, ready for the machine shop. The whole subject has been so thoroughly worked out in his mind, by means of the rare faculty which he possesses, that in nine cases out of ten the very first machine or piece of apparatus made from his drawing is found to be perfect in every minute detail, and ready for actual use. Mr. Brush has steadily pursued the policy of patenting only such as seem to give good promise of return. He has obtained and owns over fifty patents, and he has in patentable shape, ready for any future demand that may arise, a large number of inventions bearing upon the general subject which he has been investigating. Two-thirds of the patents which he has procured are sources of revenue. It was of Mr. Brush that Gambetta remarked, as he saw the commanding figure of the great American inventor at the Paris Exposition, "I do not know which to admire most—his extraordinary mental talents or his magnificent physique."

There is an entire absence in Mr. Brush of the careworn, round-shouldered, hollow-eyed, and haggard features which one pictures as the natural attributes of an inventor. In Mr. Brush we see one of the finest possible mental and physical specimens of the race; still in his early manhood, with a bright, clear eye, features full of intelligence, frank, open, courteous, of magnificent physique, six feet high, broad shouldered, with a deep and well developed chest, and a form as straight as an arrow. Success has crowned his efforts. His researches have enriched and benefited the entire civilized world, and he has reaped both honors and pecuniary reward. In 1869 the University of Michigan conferred upon him the degree of M.E. In 1880 the Western Reserve University invested him with the degree of Ph.D.; and in 1881, in connection with the Electrical Exposition held in Paris, the French Government, in honor of his distinguished inventions, services, and contributions to the world of science, decorated him Chevalier of the Legion of Honor. At the Michigan University he was a member of that famous college society, Δ K E. In politics he is a Republican; in religious faith an Episcopalian, and he is very liberal with his means to the church of his choice and to charitable institutions and societies. The Brush electric lights now shine by thousands in all quarters of the globe; in the streets, factories, stores, and dwellings; on steamers plowing the rivers, lakes, and oceans; on the war vessels of various foreign nations, as well as on the ships of the merchant marine; and the name of "Brush" is a household word on the five great continents.

TELEPHONING EXTRAORDINARY.

EXPERIMENTS in telephoning to long distances have been made, it is said, by the engineers of the International Bell Telephone Company between St. Petersburg and Bologœ (about 3,700 kilometers = 2,465 miles). Blake transmitting and Bell receiving instruments were used; and conversation could be kept up notwithstanding a rather high induction. It is but right to add that the experiments were made during the night, when the telegraph lines were not at work.

[JOURNAL OF THE FRANKLIN INSTITUTE.]

SYNCHRONOUS-MULTIPLEX TELEGRAPHY IN ACTUAL PRACTICE.

By Prof. EDWIN J. HOUSTON.

IT will interest the public generally to learn that Mr. Patrick B. Delany has successfully put into active operation his synchronous-multiplex system of telegraphy between the cities of Boston and Providence, R. I., a distance of about fifty miles.

The line is constructed of number six galvanized iron wire. For the purpose of securing one wire for operation in case of the accidental interruption of the other, and with a view to extension of the system, two wires have been strung. It will of course be understood that each of these wires is intended for separate use under any of the divisions of which the synchronous-multiplex system is capable, viz., any number from a single circuit up to seventy-two separate and distinct circuits over one and the same wire; or, as these are generally used in actual practice, into six fast or twelve slower Morse circuits, or into thirty six or seventy-two printing circuits.

When the possibilities of the Delany synchronous-multiplex system were first brought before the public, grave doubts were expressed by some, if not by a majority, of the leading electricians of the country as to the possibilities of its actual operation under the conditions of commercial practice. Many believed that, although it might be operative under the conditions of an artificial line, established in the laboratory by means of resistance coils and condensers, when put into actual operation the conditions necessary for continuous working could not be maintained.

into six separate circuits, it was worked for long periods at the rate of forty words per minute on each of the circuits so established. Dividing the line into twelve Morse circuits, it was similarly worked at the rate of twenty words per minute on each line.

Thirty-six printing circuits have been worked between the two cities at the rate of from four to five words per minute; while seventy-two printing circuits were similarly worked at the rate of from two to three words per minute.

The circuits above referred to have all been operated in one and the same direction at the same time, or have been operated one-half in one direction and the remaining half in the opposite direction, or other combinations of the same number of separate and distinct circuits have been employed.

In order to practically note the effect produced by increasing the length of the line, the two wires were joined together at Providence, thus providing one continuous circuit from Boston to Providence and back again to Boston, with separate grounds at each end in Boston. Over this double distance of about one hundred miles, the circuits were operated, as above mentioned, without any diminution of speed.

Further experiments introducing artificial resistances of 3,000 ohms, or an equivalent of about 300 miles, of line, and of 2½ microfarads of static charge, demonstrated the entire success of the system, under these conditions, with only a slightly diminished speed.

Employing the line as a sextuplex, on Saturday, July 12, 1884, 1,000 words were transmitted over one of the sextuplex circuits from Boston via Providence to Boston, and received, at the rate of thirty-five words per minute, by sound, by Morse operators, who had never seen the system before that week.

cuits, for example, obtained from a single wire may be connected at the terminal stations at the two ends of the main line where a distributing instrument is situated, by independent wires run so as to reach the outlying cities beyond. In this manner each of these cities will be furnished with an exclusive circuit through the divided wire.

With, for example, a distributer in New York, connected by a single wire with one in Boston, and divided into six Morse circuits, a single wire, extending to Providence, could be connected at Boston to the No. 1 of the six multiplex circuits, while Lowell could be connected to the No. 2 of the multiplex circuits; Portsmouth to the No. 3 of the multiplex circuits; Worcester to the No. 4 of the multiplex circuits; Lawrence to the No. 5 of the multiplex circuits; and finally Lynn to the No. 6 of the multiplex circuits, thus affording each of these six cities direct circuits over one and the same wire to New York, through the medium of the distributer at Boston, without any repetition of the dispatches.

In like manner, if so desired, six cities adjacent to New York, within distances of say from 75 to 100 miles from New York, might be connected with Boston, through the medium of the New York distributer, or the outlying cities themselves might be put into communication with each other.

Under the present system of telegraphic communication nearly all these outlying cities are compelled to send their messages on to Boston or New York, from which places they are repeated to their destination.

The connection above referred to may be better understood by reference to the figure. A and B represent the synchronized distributers situated at Boston and Providence respectively and connected with the main line wire, Q Q.

BOSTON.   PROVIDENCE
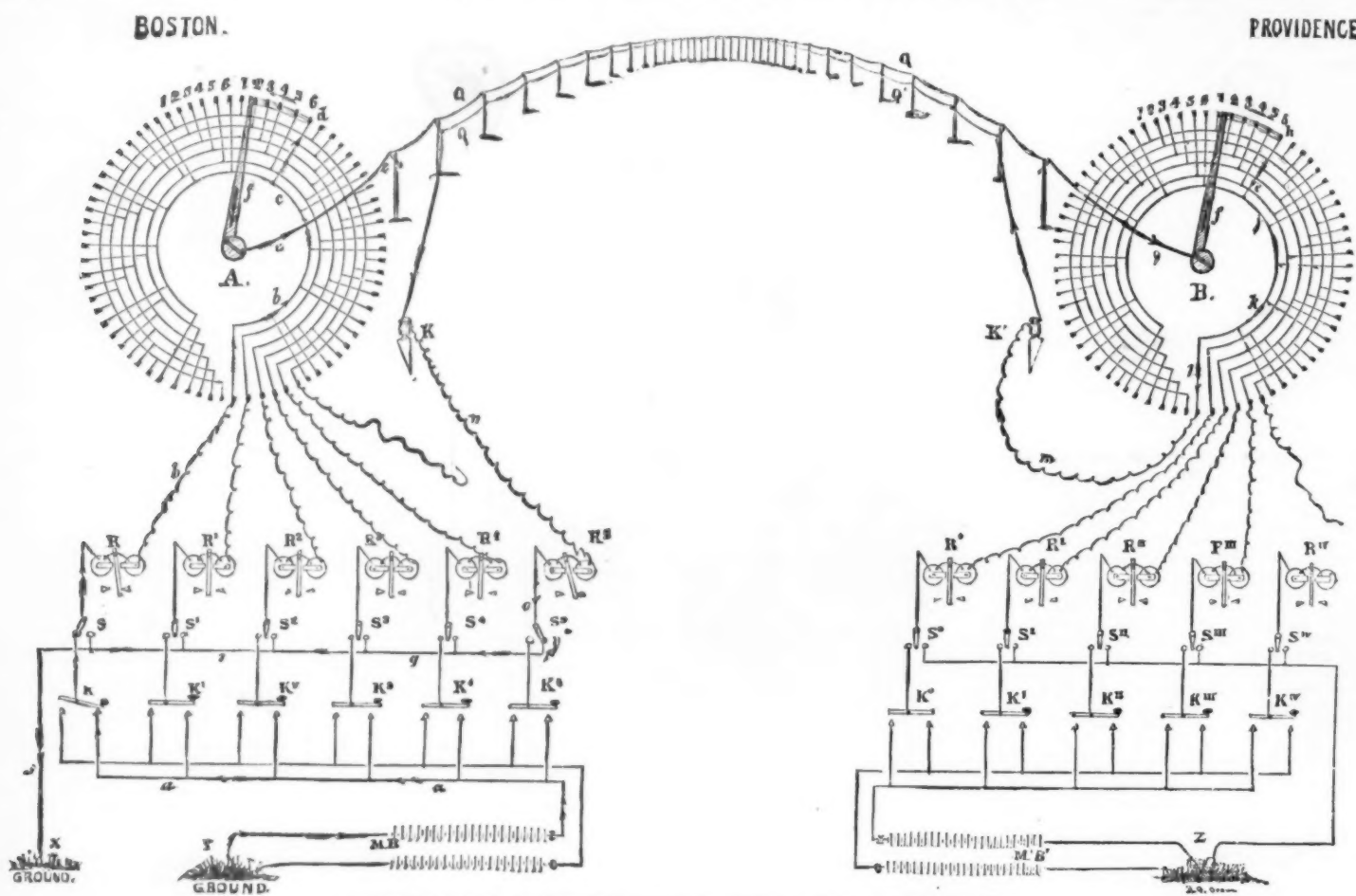
SYNCHRONOUS-MULTIPLEX TELEGRAPHY IN ACTUAL PRACTICE.

It may be interesting briefly to review some of the many objections that at the outset were urged against the practical workings of the system. As is, of course, understood, the possibility of the successful operation of the synchronous-multiplex system is dependent on the continuance of the synchronous rotation of the distributing wheel at the transmitting and receiving ends of the line. In Mr. Delany's system, as the reader will probably recall, the synchronous rotation of the disks at each end of the line is maintained by timed electrical impulses, thrown into electro-magnetic motor devices, by the vibration of similar tuning forks placed one at each end of the line. Now it was urged, and perhaps with some show of reason, that although it might be possible to maintain the synchronous vibration of these forks in a room, where any necessary adjustment of their rate of vibration could be made by an attendant, yet it would clearly be impossible to maintain such synchronous vibration at stations widely separated from each other, since the mere difference of temperature at the two stations would, unless automatically compensated for, be sufficient to throw the two forks out of synchronism.

Another difficulty that in the opinion of many presented an insuperable obstacle to the practical application of the system was the static charge of the line. It was thought that the line could not in practice be discharged with sufficient rapidity to permit the transference thereon of the numerous separate and distinct electrical impulses necessary in this system. It was feared that before the line could be freed from the charge given it by one impulse, another would be sent over it by the distributer, and that these two would necessarily interfere with each other.

These, and many other difficulties, were urged as necessarily fatal to the success of the system. It is to the credit of Mr. Delany that he has so ingeniously met and overcome all these difficulties, and has established his invention on a commercial basis. But let the actual facts of the case speak for themselves.

Dividing one of the wires between Boston and Providence

Employing the line as a duodeciplex, 1,100 words were transmitted over one of the twelve lines so provided, at the rate of twenty words per minute, and perfectly received by sound. An increase in the resistance of the line of 9,000 ohms, in addition to the normal resistance of 100 miles of wire, in the two wires joined as one, did not affect the synchronism, or prevent the perfect transmission of the messages.

The synchronous-multiplex system of telegraphy has now been in actual operation between Boston and Providence, under the various conditions above mentioned, during the last thirty days. During that entire time, the synchronism has been maintained between the Boston and the Providence instruments without ten minutes' interruption, excepting, of course, when the instruments were purposely stopped, or were interrupted for the purposes of experiment, or were disturbed by crosses or breaks in the wires of the main line.

When thrown out of synchronism by any of these causes, the instruments at the ends of the line, in all cases, came automatically into synchronism within one and a half minutes, without the intervention of the operator at either the Boston or the Providence end of the line.

Mr. Delany has availed himself of the opportunity which the additional line afforded him of trying practically things for which he believed his system adapted, and for which he originally intended it. One of the many purposes to which he showed the applicability of the synchronous-multiplex system would seem to add so greatly to its commercial value when in actual operation that it may be well to explain it at length.

Connecting at Providence one of the sextuplex circuits established in one of the wires, to the end of the second wire at Providence, a message transmitted from Boston, over the sextuplex circuit so connected, was received in Boston on the second wire clearly and perfectly transmitted.

This experiment would seem to show that the synchronous-multiplex system is applicable not only to the connection of terminal stations, whereby the wire may be divided into the numerous circuits claimed for it, but that the six cir-

The second wire, Q¹Q¹, which ordinarily has no connection with the distributers, A and B, is for the purposes of this experiment connected in the manner shown. In the figure the contacts are connected in groups of six, or in other words the main line, Q Q, is divided into a sextuplex. The trailing arms at A and B are shown in contact with one of the No. 6 contacts at d and h, respectively. Polarized relays, R, R¹, R², R³, and R⁴, are connected respectively to five of the six circuits so provided. The sixth circuit in this case, it will be observed, is left unconnected to the polarized relay, R³. The relays are connected by means of switches, S, S¹, S², S³, S⁴, and S⁵, with the keys, K, K¹, K², K³, K⁴, and K⁵, whose front and back stops are connected with the split battery, M B, grounded at Y. It will also be observed that the polarized relays, R, etc., can be connected with the keys, or with the ground at X, and can therefore be used either for transmitting or receiving.

The station at Providence is similarly provided with the polarized relays, Rᵒ, R¹, Rᴵᴵ, Rᴵᴵᴵ, and Rᴵᵛ, switches, Sᵒ, S¹, Sᴵᴵ, Sᴵᴵᴵ, and Sᴵᵛ, keys, Kᵒ, K¹, Kᴵᴵ, Kᴵᴵᴵ, and Kᴵᵛ, and main battery, M¹ B¹, split and grounded at Z, and all connected as shown.

If now, the circuits being as described, the switch, S, at Boston, be placed so as to connect the relay, R, with the key, K, a message may be sent over the main line, Q, Q, to the Providence end, where it may be connected with a receiving relay and received. Instead of this, however, this circuit is in this case connected by means of the wire, m, with the Providence end of the second wire, Q¹,Q¹. The Boston end of Q¹, Q¹ is connected by the wire, n, with the relay, R³, which we have referred to as not being connected with the remaining circuit of the sextuplex circuits. Under these circumstances the message sent from Boston to Providence by the key, K, through the relay, R, is received at Boston by the receiving relay, R³, the latter relay being connected as shown by the switch, S³, to the ground at X.

When the key, K, at Boston, is connected to its front stop as shown, an impulse goes out from the main battery, M B, and traverses the following circuit, viz., through the con-

ducting wire, *a*, *a*, to key, K, switch, S, relay, R, conducting wire, *b,b,c*, contact, *d*, trailing arm, *f*, conducting wire, *e,e*, main line, QQ, conducting wire, *g*, trailing arm, *f'*, contact, *h*, conducting wire, *i,j,k,l*, and the remaining seven contacts to *m*, second main line wire, Q¹,Q¹, and conductor, *n*, from which it passes through the receiving relay, R³, where it is received, and finally to the ground at X, through *o*, S³, *p,q,r*, and *s*.

Now the practical value of this experiment, as has already been pointed out, consists in the very evident fact that if the message can be sent from Boston to Providence over the sextuplex circuit and received back clearly and distinctly in Boston over an independent wire, then, since it makes no difference in what direction this independent wire may extend, no matter how far its distant end may be from the synchronized distributer, within say the limit of 75 or 100 miles, important cities, lying within that distance of New York, can be readily placed in independent connection with Boston, and the outlying cities of Boston can be placed in independent connection with New York by the operation of the two synchronized distributers, A and B.

Though the leg, Q¹,Q¹, in this case was but 50 miles in length, yet, from what we have already said, it is evident that much greater distances could be successfully operated in this manner. With printing instruments, since seventy-two separate circuits can be maintained, the number of cities that can be connected with one another by means of but two synchronized distributers is clearly very great.

Central High School, Philadelphia, July 17, 1884.

EXPERIMENTS ON LIGHTNING CONDUCTORS.*

A COPPER cable, 65 yards long, was fastened by 13 uninsulated iron supports to the outside of one of the walls of the Polytechnic School in Dresden. One end of this cable was carried into a well 16 yards from the building, and containing water to a depth of 6 yards, and could there be joined on to earth plates of various dimensions. By means of a connection leading from the cable into the laboratory, strong discharges from a battery of 74 Leyden jars could be sent into the cable, the spark being transmitted between two metallic balls kept at a constant distance. The arrangement will be understood by reference to Figs. 1 and 2, the first
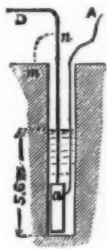

FIG. 1.

showing the well with cable, D, and earth plate, *a*, the second the battery, B, cable, D, and electrodes, X. The outer coatings of the jars were in metallic connection with the water-mains, W, by a very stout copper wire, and might therefore be taken to be always at the potential of the earth. A branch circuit, A Z *w₁*, joining the earth plate with one of the branch pipes connected with the water-mains, and having at Z two smaller metallic balls, serve to illustrate by the spark passing between them the principle of lateral discharges from a lightning conductor. Every time a disruptive discharge took place between the balls, X, in the primary circuit, another discharge occurred between the balls, Z, in the secondary circuit, and this took place notwithstanding that the earth plate, which measured 13 ft. by 1 ft. 7 in., was entirely submerged in the water of the well.
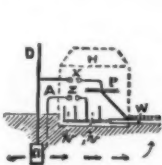
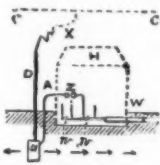For the purpose of comparison the sparking distance at X

FIG. 2.   FIG. 3.

was kept constantly at 0·4 in., that at Z was varied to get its maximum for each arrangement. With an earth plate of the size mentioned above, the earth resistance between *a* and W was found to be 2·3 Siemens units, and the maximum sparking distance at Z 0·021 in. With an earth plate half as long the resistance was 3·0 Siemens units, and the sparking distance 0.027 in. On removing the earth plate altogether, the resistance was found to be 26·1 Siemens units and the sparking distance 0·128 in. In this case an observer standing on the ground at *m*, and touching the cable at *u*, would experience a shock which the author describes as almost insupportable. At the same time each discharge of the battery was accompanied by a loud report in the well.

An iron rod 0·41 in. diameter was driven into moist ground to a depth of 6 ft., and the end of the cable, D, was joined to it (Fig. 4). In this case the earth resistance was 30 S.U.,

FIG. 4.

and the maximum sparking distance in the branch circuit was 0·138 in. Shocks could be felt by placing both hands at unequal distances from the rod on the ground, and sparks were observed between the electrodes of two wires, *b* and *c*.

* From a paper by Professor Dr. Toepler, published in the *Elektrotechnische Zeitschrift*, June, 1884.—*The Electrician.*

The analogy between the author's arrangement of a battery in connection with a lightning conductor and a thunder cloud hanging over a building will be seen by reference to Fig. 3, where G G is the cloud corresponding to the internal coating of the Leyden jars, the surface of the ground containing the water-mains corresponding to the outer coating, and X the stroke of lightning corresponding to the spark from the battery. The lateral or secondary discharge through Z must therefore be expected to take place in all cases where large metallic masses connected to earth come near to the lightning rod without being in actual metallic connection with it; and the author considers it a most important condition for the safety of a building that all metal about the building should be in the best possible metallic connection with the system of lightning conductors. The town mains for gas and water should also be included in this connection.

ELECTRIC LAMPS IN FOGS.

AN article upon electric arc lamps for lighthouses has recently appeared in the *Revue Industrielle*, in which mention is made of the relative penetrating powers of these lamps and of gas and oil burners. It is stated that the early electric lamps employed for this purpose were deceptive, as their light appeared to be absorbed by fog, and seemed to carry less power through mists than that of oil or gas. It is declared that newer tests, executed with more care, have proved the inexactitude of these early observations. Recent investigations by M. Allard upon the composition of the spectrum of the electric arc give the explanation of these facts. It is known that, among the different colored rays, the red and yellow more easily penetrate through fog; while the blue, indigo, and violet are almost completely absorbed. As the electric arc light gives a spectrum in which the refrangible rays predominate, it has been believed that it would consequently be unsuitable for lighthouses. According to M. Allard, however, the presence of these rays capable of absorption, to which the electric arc owes so much of its whiteness and brilliancy, is the cause of a corresponding augmentation of intensity in the red rays which penetrate fog (!). Thus the light of oil and gas is only 1 per cent. better, in respect of penetrative power, than the voltaic arc; and therefore it is made to appear that all the lights are of nearly equal value. If this is so, it is strange that the early observers of electric lights in fog and mist were so egregiously deceived.
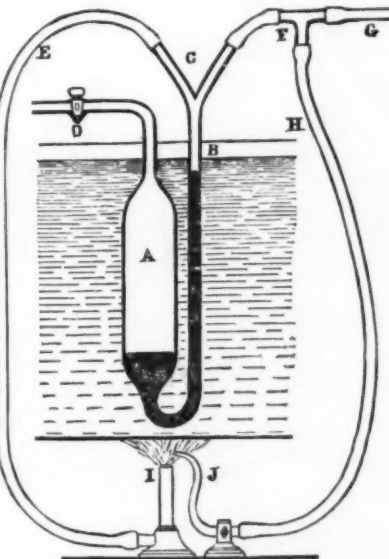

[JOUR. FRANK. INST.]

A METASTATIC HEAT REGULATOR.

By N. A. RANDOLPH, M.D.

THE instrument about to be described is adapted to maintain a constant temperature within any water or air chamber heated by gas, the degree of temperature thus maintained being adjustable at will.

Reference to the illustration shows an air thermometer so

modified that the rise of mercury in the limb, B, will cut off the gas supply, which passes through its bifurcated extremity. A second modification lies in the accurately fitting glass stop-cock, D, connected with the air chamber, A. By means of this stop-cock the tension of the air within the chamber, and consequently the height of the mercury in the tube, B, is readily adjustable. It is evident that when the mercury is forced high up in B, a relatively slight increase in the temperature of the surrounding medium will be sufficient to so expand the air in A as to force the column of mercury to the point of shut-off. On the other hand, a far higher temperature will be needed to effect the shut-off when the columns of mercury in A and B are of the same height. In practice the adjustment is effected by placing the instrument in a medium of the required temperature, the cock, D, is opened, and air slowly forced in with a syringe, until the mercurial column in B is nearly at the point of bifurcation; the precise height varying, of course, with the dimensions of the instrument, and being readily ascertained by practice.

The pressure of the gas employed must be kept quite low, otherwise, as the mercury rises above the point of bifurcation, a portion will be blown out. One of the simpler gas pressure regulators may be advantageously inserted between the source of gas supply and the heat regulator. It is well also that the diameter of the limb, C, should be somewhat greater than that of its fellow, and also that its point of junction with B should be somewhat constricted, in order that a smaller variation in temperature shall effect either the patency or occlusion of the gas exit.

When the mercury rises in B a trifle beyond the point of bifurcation, the passage of gas from G to E is arrested, and the flame from the burner, I, is at once extinguished. Were no further provision made, the vessel and its contents would soon cool sufficiently to again permit the flow of gas, which would then pass off, unburnt, through I. This difficulty is obviated by the use of a second gas jet, J, so placed as to

relight the burner, I, upon the renewed passage of gas, and so minute as not to give out sufficient heat to counterbalance that which is lost from the vessel by radiation, etc., during the temporary stoppage in the main jet. This secondary jet may be readily made from a common brass blow pipe, bent in the form shown in J, and steadily supported in such manner that its little flame may constantly play immediately above the opening of the main burner. It is usually necessary to still further reduce the small opening of the blow pipe by squeezing it with pliers, or by other means. The secondary flame is fed by a branch, fl, from the source of gas supply.

The instrument must be protected from touching the base of the containing vessel either by suspension or by the intervention of a plate of cork or other non-conductor. It must also be held steadily vertical, and should always be accompanied by a thermometer to verify its adjustment. It is also well to have each of the exposed surfaces of mercury covered by a drop or two of glycerine to prevent oxidation.

Biological Laboratory of the University
of Pennsylvania, May 29, 1884.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, AT MONTREAL.

IN the course of his address, as President of the Mechanical Section, at the meeting of the above Association, Sir F. Bramwell made the following remarks in regard to the qualifications and work of modern civil engineers, more particularly those who are engaged in the special branches of engineering:

The accomplished engineer of the present day must be one well grounded in thermal science, in electrical science, and (for some branches of the profession) in the sciences relating to the production of light, in optical science, and in acoustics; while, in other branches, meteorological science, photometrical science, and tidal laws are all important. Without a knowledge of thermal laws, the engineer engaged in the construction of heat motors (whether they be the steam engine, the gas engine, or the hot air engine, or engines depending upon the expansion and contraction, under changes of temperature, of fluids or solids) will find himself groping in the dark. He will not even understand the value of his own experiments; and therefore will be unable to deduce laws from them. Thus, if he make any progress at all, it will not guide him with certainty to further development; and it may be that he will waste time and money in the endeavor to obtain results which a knowledge of thermal science would have shown him were impossible. Furnished, however, with this knowledge, the engineer starting with the mechanical equivalent of heat, knowing the utmost that is to be attained, and starting with the knowledge of the calorific effect of different fuels, is enabled to compare the results he obtains with the maximum, and to ascertain how far the one falls short of the other. He sees, even at the present day, that the difference is deplorably large. But he further sees, in the case of the steam engine, that which the pure scientist would not so readily appreciate; and it is, how a great part of this loss is due to the inability of materials to resist temperature and pressure beyond certain comparatively low limits. He can thus perceive that unless some hitherto wholly unsuspected and apparently impossible improvement in these respects should be made, practically speaking, the maximum of useful effect must be far below that which pure science would say was possible. Nevertheless, he knows that within the practical limits great improvements can be made; he can draw up a "debtor and creditor account," as Dr. Russell and myself have done, and as has been done by Mr. William Anderson, in the admirable lectures he gave at the Institution of Civil Engineers, in December last, on "The Generation of Steam and the Thermo Dynamic Problems Involved." Furnished with such an account, the engineer is able to say, in the language of commerce, "I am debtor to the fuel for so many heat-units. How, on the credit side of my account, do I discharge this debt? Usefully I have done so much work—converted so much heat into energy. Uselessly I have raised the air needed for combustion from the temperature of the atmosphere to that of the gases escaping by the chimney." And he sets himself to consider whether some portion of the heat may not be abstracted from these gases, and be transmitted to the incoming air. As was first pointed out by Mr. Anderson, he will have to say, "A portion of the heat has been converted into energy in displacing the atmosphere;" and this so far as the gaseous products of the coal are concerned must, I fear, be put up with. He will say, "I have allowed more air than was needed for combustion to pass through the fuel, and I did it to prevent another source of loss—the waste which occurs when the combustion is imperfect;" and he will begin to direct his attention to the use of gaseous or of liquid fuel, or of solid fuel reduced to fine dust (as by Crampton's process), as in these conditions the supply may be made continuous and uniform, and the introduction of air may be easily regulated with the greatest nicety. He will say, "I am obliged to put among my credits loss of heat by convection and radiation, loss by carrying over particles of water with the steam, loss by condensation within the cylinder, loss by strangulation in valves and passages, loss by excessive friction or by leakage;" and he will as steadily apply himself to the extinction or the diminution of all such causes of loss as a prudent Chancellor of the Exchequer would watch and cut down every unproductive and unnecessary expenditure. It is due to the guidance of such considerations as these that the scientific engineer has been enabled to bring down the consumption of fuel in the steam engine—even in marine engines such as those which propelled the ship that brought us here—to less than one-half of that which it was but a few years back. I anticipate from the application of thermal science to practical engineering that great results are before us in those heat motors, such as the gas engine, where the heat is developed in the engine itself.

With respect to the application by the engineer of electrical science, it is within the present generation that electricity has passed from the state of a somewhat neglected scientific abstraction into practical use. Thanks to the application of Faraday's great discovery of induced electricity, there has been, during the last quarter of a century, the progressive development of the dynamo machine, whereby the energy of ordinary motors, such as steam engines, is converted into electrical energy, competent to deposit metals, to fuse them, to light not only isolated buildings, but extensive areas of towns and cities, and to transmit power to a distance, whether for manufacturing purposes or for the railway or tramcar; and thus the miracle is performed of converting a waterfall into a source of light, as at Sir William Armstrong's house, or into the origin of power for a railway, as at the Giant's Causeway. To the application of electrical science is due the self-exciting of the dynamos and the con-

struction of secondary batteries, enabling a development of electricity to be continued for many hours. In the United Kingdom general electric lighting—that is, the lighting of large sections of a town from a central station—has been stopped by the most unwise, because most unjust, conditions imposed by the Electric Lighting Act of 1882.

To pass to another important branch of engineering—water supply. The engineer dealing with a district to be fed from the surface will find himself very deficient if he have not the power of applying the science of meteorology to the work he has in hand. He must know, not the average rainfall (for that is of but little use to him), but the maximum and—most important of all—the minimum rainfall over a consecutive period of years. The maximum, so that he may provide sufficient channels and by-washes for floods; and the minimum, so as to provide sufficient storage. He must know what are the losses by evaporation, what are the chances of rust interfering with his filters and with his distributive plant. The chemist and the microscopist have their sciences applied, to ascertain the purity of the intended source; and, as in the case of Clark's beautiful process, by the application of chemistry, water owing its hardness to that common cause, carbonate of lime, is rendered as soft as the water from the mountain lake.

Taking that other branch of engineering commonly coupled with water—viz., the supply of gas—the engineer is helpless without the application of chemistry. From the
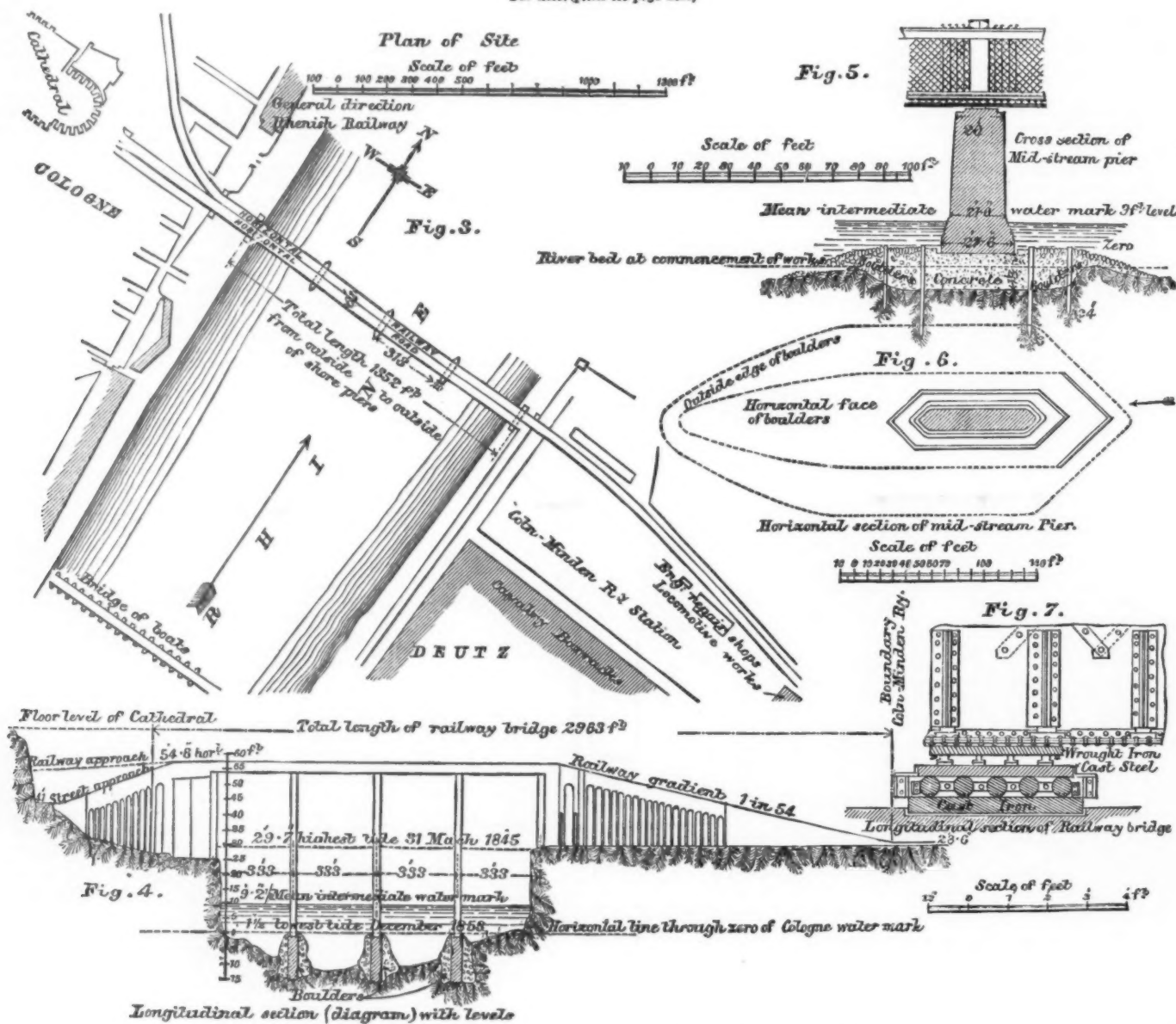
structs, nor where he can in safety make his enormous embankments. In this continent of vast lakes, one feels it must excite a sensation of the ridiculous when a Welsh "lake" is spoken of; but I must ask you to believe you are in Lilliput, and to imagine that the "Bala Pond," of 1,100 acres in extent, is really "Bala Lake," as it is called. Within a few miles of that, our friends at the other end of the Atlantic steam ferry—the inhabitants of Liverpool—are now constructing, under the engineering advice of Mr. T. Hawksley, water-works which will involve the formation—I believe one may safely say the reformation—of a lake, of practically the same area as that of Bala, some 80 feet in depth, and containing between the overflow and the point of lowest discharge nearly 12,000 million gallons. This lake will be made by the throwing, from side to side of the valley, of a solid stone bank, 100 feet above the ground, 140 feet above the deepest part of the foundations, and 113 feet thick as its widest part. Contrasted with Lake Superior, this new lake will be small—a thing demanding a microscope even; but the bursting of the wall would liberate a body of water sufficient to carry death and ruin throughout a considerable district. It is, therefore, in the highest degree important that, whether he be constructing a solid stone wall, or the more common earthen embankment with a puddle trench, the engineer should so apply geological science as to insure the safety of his work. But in those cases where the water-works engineer has to derive the supply from under-

and talent he combined a simplicity, a modesty, and an affectionate disposition that endeared him to all.

RAILWAY AND ROAD BRIDGE, COLOGNE.

Cologne, the chief town of Rhenish Prussia, was the Ubiorum Oppidum of 37 B.C., but in 50 A.D. became the Colonia Agrippina, in honor of the Emperor Claudius' wife, who founded there a colony of Roman veterans. Its cathedral, one of the noblest specimens of Gothic architecture, was begun in 814 A.D., burnt to the ground in 1248, recommenced between 1270 and 1275, and only completed in 1881, its two magnificent towers, more than 500 ft. high, being visible for miles around of the level country. Cologne is a fortress of the first rank, forming a semicircle with the Rhine as diameter, the opposite town of Deutz being the tête du pont. Although so early as 308 A.D. Constantine the Great began a bridge over the Rhine, there was, until 1859, no better communication between Cologne and the manufacturing towns of Deutz, Kalk, etc., on the opposite side of the river, than a bridge of boats, which is still used. But the great inconvenience and loss of time ensuing from the unmooring, floating aside, and removing of a barge, to allow a vessel to pass, together with the desire for uninterrupted railway communication from east to west, led to several projects being made for a combined railway and road bridge that should afford a waterway for vessels of the largest class.

Plan of Site
Scale of feet

Fig. 3.

Fig. 5.

Scale of feet

Cross section of Mid-stream pier

Mean intermediate water mark 9 ft. level

River bed at commencement of works

Fig. 6.

Horizontal face of boulders

Horizontal section of mid-stream Pier.
Scale of feet

Fig. 7.

Floor level of Cathedral

Total length of railway bridge 2963 ft.

Railway gradient 1 in 54

Fig. 4.

Longitudinal section (diagram) with levels

Longitudinal section of Railway bridge

Scale of feet

RAILWAY AND ROAD BRIDGE, COLOGNE.

examination of the coal to be used, to the testing of the gas to be supplied, there is not one stage where chemical science is not necessary. The consumer requires gas which shall be as nearly as possible a pure hydrocarbon of high illuminating power; and it might well have been that a person to whom was delivered the crude gas as it issued from the retort would have said, "Certain things may be separated out more or less, but to practice on a wholesale scale the delicate operations which will be needed to cleanse the illuminating gas from its multifarious accompanying impurities is a hopeless undertaking, and must be so if for no other reason than this—the excessive cost that would be entailed." But what are the facts? Although I, for one, do not like to sit in a room where gas is burnt, unless special provision is made for taking away the products of combustion, the engineer of the present day, thanks to the application of chemical science, delivers gas to the consumer in a state of comparative purity (although it may have been made from impure coal), which but a few years ago would have been deemed impossible. So far is this improvement from being attended with extra cost, that the residual products now not uncommonly all but pay the entire cost of the coal, and in some rare instances even leave a slight profit to go toward the charge for labor.

I have already spoken of the engineer supplying towns by water collected from the surface. Even he, however, must have a knowledge of geology, for without it he will not know what places are apt for the huge reservoirs he con-

ground sources, the application of this science is still more necessary. He must know whether he is likely to find a water-bearing stratification at all, and, if so, where it receives the rain from heaven, and the extent of the area which receives it; in what direction the water travels through it; what is the varying height of water in the different parts of the stratification giving the "head" to produce that travel; how far this height is likely to be affected by the pumping of the desired quantity; whether, if near the overflow into the sea, the pumping is likely to reverse the direction of the current, and to bring back brackish water; and whether the rocks are of such a character as to be liable to yield a water impregnated with iron or with lime, and whether these water-bearing rocks are accessible from the surface without the execution of costly and laborious work in passing through overlying stratifications of an unfit, or it may be even of a dangerous, character. With regard to that most important part of the work of Section D (Biology) which relates to "germs" and their influence upon health, the engineer deals with it thus far: He bears in mind that the water supply must be pure, and that the building must be ventilated, and that excreta must be removed without causing contamination. Thus the water-works engineer, the warming and ventilating engineer, and the sewage engineer can (and do) all of them profit by the labors of this section.

In closing his address, Sir F. Bramwell paid a fitting tribute to the memory of Sir W. Siemens; remarking that few more gifted men had ever lived, and that with all his ability

Ultimately the design of Hof Baurath Professor Strack was adopted; and the works were begun in 1855, King Frederick William IV. of Prussia laying the foundation stone of the west shore pier. In the following year the east shore pier and the river piers were begun. By the end of 1857, two spans were finished; and on 3d October, 1859, the bridge was opened to the public. It was finally completed in 1862, with the exception of the bronze equestrian statues, one of which is shown in the view, and these were erected in the following year.

The site chosen is a prolongation of the center line of the cathedral, through the cross in the chancel, striking the northern side of the Köln-Minden Bahnhof on the opposite side of the river, which it cuts at right angles. The street leading from the bridge to the cathedral is on the center line, being at the latter point about 38 ft. above the datum. From the cathedral to the river the ground falls to 25 ft. above datum, the already existing wharf wall being laid at the level of 24 ft. Close under this wall the river bed was at the level of zero before the piers were made, and then fell regularly until, at about one-third the breadth of the stream, it had a level of 8 ft. below datum, when it rose regularly to zero at a distance of about 200 ft. from the right bank, and at the latter point attained a height of 8 ft. above datum. The bank itself rose with a slope of 1 and 1¼ to 1 until it reached a height of 28 ft. above the datum, from which point the ground is nearly horizontal. As was anticipated, the scour of the river has deepened the channel under the right bank

and also between the river piers; but repeated gauging showed that no change has taken place since 1860.

The highest water mark at which navigation can be carried on is 25 ft. above datum, though practically the steamboat traffic ceases when 18 ft. is attained. The underside of the superstructure is laid at 53 ft. above datum, so that the largest steamers and sailing vessels can pass under the bridge, with their chimneys and masts lowered, at all times when the navigation of the Rhine can be carried on.

At Cologne the Rhine flows toward the north; and the position of the left shore pier was determined by the then recently constructed wharf wall, a 17 ft. roadway being retained between the pier and the river. The right shore pier is built so far from the river as to leave a 12 ft. towing path between it and the 9 ft. wall. The shore piers, which have no batter, are 20 ft. wide in the direction of the center line of the bridge. The three river piers are the same width at the top—also in the direction of the center line—but have a batter of 6 in. on either side, so that they are 21 ft. wide at about 10 ft. above datum. Here they spread out with eight perpendicular steps, 18 in. high, to 27 ft. 6 in. on the pile and concrete foundation,. The total length of the bridge between the outsides of the shore piers is 1352 ft.; and, as the total width, between these two points, of the roads, wharves, right bank slope, and of the piers at a level of 9 ft.—the mean intermediate water mark—is 149½ ft., it follows that

it is 7½ in. The diameter of the rivets is generally 1 in., which is increased to 1⅛in. in the neighborhood of cover plates. The heads are slightly countersunk. The sectional areas of the four sizes of angle iron used are 6, 4·4, 3·25, and 2·6 square inches, the weights per running foot being respectively 19·9, 16·6, 10·7, and 8·6 lb. The railway and road bridge, irrespective of masonry, cost about 946 thalers, or £140. per running foot, and about 18½ thalers, or £2 14s, per square inch of platform.—*The Engineer.*

THE FORTH BRIDGE.*
By B. BAKER.

Two years ago I read a paper on the proposed Forth Bridge at the Southampton meeting of the British Association.† Until the other day I had not since glanced at the paper, and a reperusal was in many respects suggestive; for during the past two years the works have progressed, and some of the theories advanced in the first paper have been put to the test of actual practice. In one respect the reperusal was a painful one, for the opening sentence contained a reference to Sir William Siemens, and I was reminded of the loss of a friend who took the greatest interest in the Forth Bridge, and whose vast experience and matured judgment could always be drawn upon in times of doubt or difficulty.

Taking up the narrative of the proceedings from the date

has been laid out in shops and yards for the manufacture of the 1,700 ft. span steel girders and for other purposes. These shops are in direct communication with the North British Railway, and are connected by an incline and winding engine with a temporary timber viaduct 2,200 ft. in length, and 50 ft. in width, extending from the South Queensferry shore to the first of the groups of four cylindrical iron caissons which constitute the lower portions of the main piers of the bridge. At Inch Garvie, stores and offices have been built, and as this is an exposed island in the middle of the Forth, the staging for the pier work is of iron pinned to the rock. Similarly at North Queensferry, on the Fife side of the Forth, stores, offices, and iron staging have been erected.

The state of the works at the present time is as follows:

PLANT.

The plant includes 14 steam barges, launches, and other vessels; 22 steam, 12 hydraulic, and 38 hand-power cranes; 28 single and double engines for shop machines, hydraulic work, air compressing, electric lighting, pumping, and other purposes; also gas furnaces for heating the steel plates, a 2,000 ton hydraulic press for bending them, and planing machines, multiple drills, hydraulic riveters, and other specially designed tools too numerous to mention. Having reference to the novelty and magnitude of the work and the

RAILWAY ROAD BRIDGE OVER THE RHINE, COLOGNE.

the total clear water-way is 1202½ ft., which is made up as follows:

	Ft.
The two river spans (333—23½)×2	619
The right shore span, 333—(22+9¼+11¾)	289¾
The left shore span, 333—(27½+11¾)	293¾
Total clear waterway	1202½

The superstructure consists of four lattice girder spans, all 333 ft. between centers of piers, and of 313 ft. clear opening. The common piers carry two perfectly independent bridges; together 61 ft. wide over all, with a foot space between them. The northern portion, 24 ft. wide in the clear, serves for a double line of railway, and the southern, 27 ft. wide in the clear, has a 16 ft. roadway in the middle, with footways 5½ ft. wide, and 2 in. rising to 5 in. above the roadway, one on each side. Neither trains nor wagons are allowed to pass over the bridge at a rate of more than five miles an hour; and engine drivers are forbidden to open their whistles or cylinder cocks while on the bridge, the necessary signals being given by horns.

All the longitudinal dimensions of the superstructure depend upon the distance between the cross girders, as they must be either multiples or aliquot parts of this dimension. In the railway bridge the distance between centers of cross girders is 5 ft . This makes the general dimension of the longitudinal girder plates 10 ft. and the diagonal distance—in a horizontal line—between the lattice bars, 2¼ ft. The vertical distance between the innermost rows of rivets is 8 ft. ×2¼ ft. = 20 ft., while the longitudinal girders are 25 ft. deep over all. The rivets are spaced the ⅒ part of 5 ft. that is to say, 3¾ in., except in the last division, where

of my last paper, I may state, in the first place, that five tenders were submitted for the construction and erection of the bridge, the amounts varying from 1,487,000l. to 2,301,-760l., and that the contract was finally let to Messrs. Tancred, Arrol & Co., on the 21st of December, 1882, for 1,600,000l., which was within 5,000l. of the estimated cost of the work as prepared by Mr. Fowler and myself for Parliamentary purposes.

Total length of viaduct included in this contract is about 1½ miles, and there are:

2 spans of 1,700 ft. each.		
2	"	675 "
15	"	168 "
5	"	25 "

Including piers, there is thus almost exactly one mile of main spans, and half a mile of viaduct approach. The clear headway under the center of the bridge is 150 ft. above high water, and the highest part of the bridge is 361 ft. above the same datum. Each of the three main piers consists of a group of four cylindrical masonry and concrete piers, 49 ft. in diameter at the top, and from 60 to 70 ft. in diameter at the bottom. The deepest pier is about 70 ft. below low water, and the rise of tide is 18 ft. at ordinary springs. In the piers there are about 120,000 cube yards of masonry, and in the superstructure about 45,000 tons of steel.

Operations were commenced in January, 1883, so the works have now been some twenty months in progress, and about 170,000l. have been expended in plant and temporary works, and 200,000l. in the permanent works of the bridge. At South Queensferry an area of about 20 acres of ground

* Paper read before the British Association, Montreal.
† See SCIENTIFIC AMERICAN SUPPLEMENT, No. 354, also No. 317.

amount of preliminary preparations required, it may be considered that fair progress has been made during the past twenty months.

No special difficulties were encountered in founding the viaduct piers, notwithstanding their exposed position. Except in two cases, the piers rest on the rock, and they were executed in half-tide or whole-tide cofferdams, which call for no special remark. The cofferdam for the south cantilever end pier was necessarily a very substantial structure, being a quarter of a mile from the shore. It measured 126 ft. by 75 ft. over all, and had a double row of whole timber poles, with 4 ft. of puddle between them, and internal struts, chain cable ties, and external raking struts and piles of great strength and solidity. A highly satisfactory bottom on bowlder clay of rock-like hardness was found at a depth of 35 ft. below high water. The masonry of the viaduct piers and cantilever end piers consists of an Aberdeen granite facing, averaging a little over 2 ft. in thickness of rock-faced work, backed up with cement concrete or with rubble masonry set in cement, and bonded, about every 12 ft. in height, with courses of large stones carried across the entire area of the piers.

The main piers have on the whole, perhaps, given more trouble than was anticipated. On the Fife shore the whinstone rock bottom falls with a rapid slope of about 1½ to 1 to deep water, and it was necessary to step this slope for the masonry. Diamond drills worked from an iron stage were employed for the subaqueous blasting; but the removal of the rock proved a most tedious affair, and a substantial timber and clay cofferdam had, after all, to be constructed for one of the piers. With some trouble the other pier was built within a makeshift half-tide dam, made up partly of the 60 ft. diameter permanent iron caisson below low water,

with a temporary iron caisson attached to it, the whole made tight to the rock as far as might be with concrete and clay filled in between the caisson and a few buckle plates. At Inch Garvie similar delay and trouble were experienced in carrying out the shallow piers. Some of the work could only proceed at low water of spring tides, and it generally happened to blow hard just at that long-waited-for moment. Tidal work, and even half-tide work, are proverbially slow and worrying; but we were all determined that, as the rock varied in quality, no foundation should be put in until the bottom had been laid dry. By perseverance and patience this has hitherto been accomplished, and we have the satisfaction of knowing that both the rock foundation and masonry are unexceptionable in strength and solidity. In our shallow rock foundations at the Forth we had much the same problem to deal with as Stephenson encountered thirty years ago, when building the fine bridge across the St. Lawrence at this city, and our contractors dealt with it in much the same way. I am not concerned to defend the operations, as such details are usually left to those responsible, namely, the contractors. Where speed is required. I am satisfied that in most cases pneumatic appliances offer incomparable advantages over cofferdam work on a rock bottom. French contractors generally resort to pneumatic caissons of ordinary type in depths exceeding 15 ft., but have employed, with great advantage, modifications known as the *caisson-batardeau*, the *bateau-plongeur*, etc., in depths as little as 6 ft. The six weeks required to build a pier with the aid of pneumatic appliances may often be taken up in stopping the leaks of a cofferdam or rock bottom. English contractors are not much accustomed to pneumatic appliances, other than an ordinary diving dress, and rarely resort to them. A diving bell with shaft of access and air lock was provided and mounted on traveler complete at the Forth, and compressed air drills were fitted in the working chamber, but no use has hitherto been made of the apparatus.

The lower part of the South Queensferry main pier consists, as already stated, of a group of four pneumatic caissons 70 ft. in diameter. In the contract the option was allowed of sinking open-topped caissons by dredging inside, but, after experiencing the extreme hardness of the bowlder clay, we were all agreed that it would be preferable to resort to the pneumatic process. Owing to the slope of the clay the four caissons will be sunk to varying depths, ranging from 68 ft. to 88 ft. below high water. The caissons, which were built on shore, launched, and floated into position, are 70 ft. in diameter at the cutting edge, and taper 1 in 46 to facilitate sinking. At 1 ft. above low water, which is the top of the permanent caisson and commencement of the granite-faced masonry, the diameter is 60 ft. A working chamber 7 ft. high is provided at the bottom of the caisson, the roof of which is supported by four strong lattice girders 18 ft. deep, and cross girders 3 ft. deep spaced 4 ft. apart. An internal skin 7 ft. distant from the external skin, and vertical diaphragms, form pockets which can be filled with concrete at any point where, owing to the slope of the ground and the varying hardness of the silt and clay, a heavier pressure is desired to force down the caisson. Three shafts, 3 ft. 6 in. in diameter, with air locks at the top, pipes for admitting water and ejecting silt, and other of the usual appliances, are provided. The air locks for passing out the clay and bowlders as designed by Mr. Arrol and myself have, instead of the usual hinged doors, two sliding doors like horizontal sluice valves, across the 3 ft. 6 in. shafts, which are worked by little hydraulic rams, or by hand, and are interlocked like railway points and signals, so that one slide cannot be opened until the other is closed. Mounted on the side of the air lock is a steam engine which, by means of a shaft passing through a stuffing-box in the side of the air lock and a drum inside, winds up the excavated material in skips containing one cubic yard. The operation of hoisting, opening slides, and discharging is rapidly performed, so the two locks have a large working capacity. A third air lock, with side doors, ladder, and hoist, is also provided for the men. The air compressing plant consists of three engines with steam and air cylinders 16½ in. in diameter by 24 in. stroke, ample power being furnished by boilers of the locomotive type erected on the staging.

Reference has already been made to the two shallow piers at Inch Garvie, but there are also two deep piers which, being on a very irregular and sloping rock bottom, have required much consideration. It was finally decided to level a bed roughly with bags of sand, and to float out pneumatic caissons, and excavate the rock until a level bed was cut. Probably Mr. Fowler and I would not have adopted this precise plan if we had been contracting, although we might have resorted to the pneumatic process, but as M. Coiseau, a contractor of great experience in such work, offered to sub-contract for the sinking of the caissons at fair rates, we did not object. These caissons are 70 ft. in diameter at the bottom, and the rock slopes from 14 ft. to 19 ft. in that length, the lowest point being 75 ft. below high water.

All of the pneumatic caissons will be filled with concrete up to low-water mark, the mixture being 27 cubic feet of broken whinstone, 7 cube ft. of sand, and 5½ cubic ft. of cement, which together make a full yard of concrete, having a crushing resistance of about 50 tons per square foot.

Above low water the cylindrical piers, which are 49 ft. in diameter at the top, 55 ft. at the bottom, and 36 ft. high, consist of the strongest masonry, the hearting being flat-bedded Arbroath stone with both horizontal and vertical bond, and the facing Aberdeen granite, the whole set in two to one cement mortar, and built in the dry within temporary wrought-iron caissons. In the shallow piers where the rock is stepped, the masonry is carried down to the rock itself, and wrought-iron hoops 36 in. by 1¼ in. bind the bases of the piers. At the top of all the piers 18 in. by 1½ in. hoops, and midway down 18 in. by ¾ in. hoops, are also built in, and it is believed that these cylindrical masses of masonry are as completely monolithic as can be attained or desired. In each cylindrical pier there are forty-eight steel bolts 2½ in. in diameter and 24 ft. long to hold down the bedplates and superstructure of the main spans.

A few words now as to the manufacture of the superstructure. About 42 miles of plates have to be bent for the tubular compression members, and the best method of doing this became a question of great practical importance. Bending cold did not answer, as the true curvatures could not be so attained. Theoretically, a 10,000 ton hydraulic press would be required to bend, truly, our 16 ft. by 1¼ in. thick steel plates, and practically a 2,000 ton press was of no use. Heated in a gas furnace, the plates bent readily, but distorted considerably and irregularly in cooling. Covering with ashes, packing up, and a variety of expedients were tried before the proper method was hit upon, which was to bend the plates hot and to give them a straightening squeeze afterward when cold. Uniform heating is secured by admitting

the gas near the door and midway along the furnace, and an important incidental advantage of the use of tubular compression members thus is that every plate gets relieved from any internal strains which may have been set up by shearing or improper usage at the steel works, which is of the greater moment as steel having the comparatively high tensile strength of 34 to 37 tons per square inch is used for the compression members.

Some alarm was occasioned at the works by certain 1¼ in. thick plates breaking like cast iron on being bent cold to the flat radius of 6 ft. I felt certain, however, that the Landore steel was not at fault, as our inspectors test a shearing from every plate by bending it round a radius of 1½ in. after being made red hot and cooled in water. On investigation I traced the cause of the fracture in the local damage the plates received from shearing. What the damage consists in is an unsolved riddle. It cannot extend more than ¼ in. from the edge, because planing to that extent relieves the plate, and yet it affects the entire width, for the 4 ft. 6 in. plate snapped as readily as the 1 in. wide strip sheared from it. Neither can it arise from "nicking" by bad shearing, because making the plates red-hot cures the evil, though the "nicking," if previously existent, remains as visible as ever. Practically, the important point of interest to bridge builders is that with planed edges and drilled holes we have had no mysterious fractures, but the Forth Bridge plates have behaved as a material having as the higher limit a tensile strength of 37 tons per square inch and an elongation of 17 per cent. in 8 in. should behave. Our specification for steel in compression is 34 tons to 37 tons with an elongation of 17 per cent., and for steel in tension 30 tons to 33 tons with 20 per cent. elongation. The strength rarely varies as widely as the stated limits, and the elongation averages some 3 per cent. more. One of the plates which fractured from sheared edges when bent cold was tested by me in a variety of ways. A specimen made red hot and cooled in water at 80 deg. stood 38·3 tons per square inch and elongated 21 per cent. Another specimen made hot and allowed to cool in air stood 36·6 tons and also elongated 21 per cent., while one planed from the plate direct without heating failed with 34·3 tons, but extended 25 per cent. For practical purposes, therefore, it mattered little how the plate was treated, provided the effect of the shearing was eliminated by planing or by heating.

When bent, the plates are planed at the edges in the usual way, and at the curved ends by a specially designed radial machine. They are then, with the internal stiffeners, temporarily built into a tube round a mandrel, and drilled through plates, covers, and bars at one operation. Four specially designed annular drill frames, surrounding the tubes, and furnished each with ten traversing drills, capable of attacking every hole, travel along lines of railway in the building yards, so laid out that four lengths of tube, each of about 400 ft., can, if desired, be dealt with at once. In a 16 ft. length of diameter tube there are about 1,600 holes to drill through from 2½ in. to 3½ in. thickness of steel, which operation takes about fifty-two hours' working of the drills. Continuous working is, of course, not possible, as the machine has to be advanced every 8 ft., which is the shift of the butts in the plating of the large tubes.

Over the piers the arched tubular lower member forms a connection with the upper bedplates, the vertical and diagonal tubes, and the lateral and vertical cross bracing, so that considerable thought had to be given to the details at this point. A full-sized model was prepared, and different modes of arranging the junctions were set out and modeled. Finally it was decided to gradually change the tubular lower member into a box form with one rounded upper corner, where it meets the skewback or part over the pier, and by internal vertical and horizontal diaphragms, to make the latter a cellular structure of enormous strength and stiffness, offering facilities for attachments in any required direction. Several layers of plates form the bottom of this skewback, and constitute what may be termed the "upper bedplate" of the bridge. The "lower bedplate" consists of similar layers of plates riveted together and bolted to the pier; and the two bedplates are free to slide on each other within certain limits to be referred to more particularly hereafter. The layers of plates run longitudinally and transversely, to meet the different stresses; and, after the edges are planed, the plates are fitted together, clamped between girders, and drilled by special machines through their whole thickness. About 1,000 lineal feet of 1¼ in. holes have to be drilled in each bedplate, which in practice with the 8-drill machine takes about eighteen days, including stoppages. In the upper bedplates holes about 11 in. square, with corners rounded to a 3 in. radius, are required, in some instances, to clear the nuts of the holding-down bolts, and these are cut readily by a simple tool devised by Mr. Arrol. In other cases, 12 ft. diameter recesses, 2 in. deep, have to be bored for what may be termed a huge key or dowel, which will connect the upper and lower bedplates, but allow a slight rotation; and this also requires a special tool.

The tension members and cross bracing generally consist of box lattice girders which are drilled by traveling machines of similar type to those already referred to in connection with the tubular members. All of the rivets are of steel, having a tensile strength of about 27 tons, an elongation of about 30 per cent., and a shearing resistance of from 22 tons to 24 tons per square inch. It is hardly necessary to state that hydraulic riveting will be used throughout. The nuts and washers of the holding-down bolts and some other parts are of cast steel, having a tensile strength of 30 tons per square inch, and an elongation of 8 to 10 per cent. It may be interesting to mention that the contractors have used steel in preference to iron in some parts of the temporary works, and that at their request the 168 ft. span viaduct approach girders were changed from iron to steel with a view to save expense.

The two years' additional consideration given to this bridge since the date of my first paper has led to no modifications of importance in the design, or in the weight of steel required for the construction, a satisfactory result which is largely due to the care and ability of my colleague, Mr. Allan Stewart, who has had charge of the detailed calculations and designs from the inception of the undertaking. Originally the cantilevers had a varying batter toward each other from 1 in 7½ at the piers to vertical at the ends, where they meet the central girder. We have now made the central girders slope inward and maintained the batter 1 in 7½ throughout, thus getting rid of the previous "winding" which somewhat complicated the details of the cantilever, and at the same time preserving and emphasizing the pyramidal form of cross-section characteristic of the design. In models of the bridge a feeling of great solidity results from this feature, as will be the case no doubt in the bridge itself, of which a geometrical elevation necessarily gives but a poor idea.

We have also modified the attachment of the superstructure to the piers. Formerly the intention was to put an

initial stress upon the 12 ft. tubes between the double piers as described in my first paper, and to bolt the superstructure rigidly to the masonry. Now we secure the superstructure to one only of the four cylindrical piers in each group by the great circular key already referred to, and permit a certain amount of sliding on the others. Owing to the enormous size of the structure, elastic deformations which may be neglected in ordinary cases have to be provided for. A very great deal of consideration has been given to this important point, and the calculations have necessarily been complex and tedious, but we think we have now made the best disposition attainable to resist all possible and improbable hurricanes striking the bridge locally or throughout the whole span, and all variations of temperature likely to be met with at the Forth.

The question of clothing the tubes between the piers with some non-conducting material will be left for future settlement, after the movements under changes of temperature have been registered by the tube itself. Fortunately we are not troubled with Canadian variations of temperature and the correspondingly great changes of form in metallic structures. At the new Clyde Viaduct in a length of 376 ft. the observed annual range is 2 in., or a fraction over half an inch in the 100 ft., and this is an open lattice construction, while the Forth Bridge horizontal members between the piers are closed tubes. Obviously during the early stages of erection, before much weight comes on the bed-plates, the tube will be practically free to expand and contract. Ultimately, when the whole weight of the completed structure rests on the piers, the friction between the two surfaces of the upper and lower bed-plates will probably be sufficient to prevent movement except under extremes of temperature and heavy wind pressure of rare occurrence. The attachment of the superstructure to the piers partakes thus of the character of a safety friction clutch. Movement will not occur under ordinary circumstances, and if an excessive shock from some unforeseen cause arise on the superstructure, it can only be transmitted to the masonry of the pier through the sliding surface of the upper and lower bed-plates. Should a wave of deflection from the impact of a tornado pass along the great cantilever, as some critics suggest, then it would be arrested by skidding, as an express train is arrested, and not by running into a buffer stop.

Provision is made for lubricating the surfaces, and as the results of experiments made by myself during the past years, probably some crude petroleum will be applied to the bed-plates every time paint is applied to the rest of the bridge. Calculations have been made of the extent of sliding and of the stresses on the piers under the twisting action of a hurricane blowing on one cantilever, while the balancing cantilever is in a dead calm, and various coefficients of friction have been assumed.

During erection, sliding can, if desired, be made practically free by carrying one cantilever further out than the balancing one, and so relieving two out of the four bed-plates of weight. In the completed bridge the position of the bed-plates could be adjusted by temporarily loading the end of a cantilever.

Experiments on friction vary considerably, but when such large surfaces as 2,200 square feet, which is the joint area of the four bed-plates of each main pier, are concerned, there would no doubt be an equalizing effect which would make the proper coefficient of friction for the bed-plates approximate to the mean of the results obtained with a number of experiments on small areas. The coefficients obtained by Morin for iron on iron greased ranged from 0·09 to 0·115, and with the grease wiped off, 0·16 to 0·19, the pressure being about 27 tons per square foot, or considerably greater than that on the Forth Bridge bed-plates. On a large scale the mean values of coefficients for different surfaces are derivable from launching ways of ships, brake experiments, and other data. In launching ways the coefficient must be singularly small, for with declivities of ½ in. to 1 in. in the foot ships not only start, but acquire a velocity of ten miles an hour or more very quickly. In some of Mr. Denny's experiments it would appear that even with this flat slope the velocity acquired was fully half that which a body would attain falling freely, so the retarding friction during motion must be very small. Again, the coefficient friction at starting could not exceed 0·06, but of course in ordinary launching ways the pressure per square foot, and the character of the surfaces, are different to those in the Forth Bridge, though the total weight of the moving mass may be the same, and the facts are worth mentioning on that account. Brunel's broadside launch of the Great Eastern in 1857 affords, however, valuable data directly applicable to our sliding bed-plates, for the weight of the ship was 12,000 tons, and the launching ways were iron on iron somewhat rough on the surface, and imperfectly lubricated or not lubricated at all. As a result of experiments with a small section of the launching ways, the inclination was made 1 in 12, as it was thought a small force would then start the ship, and a similar force restrain it from acquiring undue velocity, the observed coefficients of friction ranging from 0·125 at starting to 0·067 at moderate velocities. On commencing the launch an estimated force of about 500 tons was required to assist gravity on the 1 in 12 incline, hence the starting coefficient with the 12,000 ton load would be about 0·125, as in the model. Again, when started, the 1 in 12 was more than sufficient, for the vessel ran on some 3 ft. or 4 ft., and, spinning around the handles of the winches, injured five men. Subsequently, however, owing to want of rigidity in the ways, rusting of the rails, or some other disturbing cause, considerable trouble was experienced, and successive additions had to be made to the hydraulic presses during the three months occupied in the launch. For the last 30 ft. or 40 ft. Brunel estimated the power required, inclusive of gravity, at one-quarter of the weight, or double that which started the ship at the top of the launching ways.

Railway trains are not as heavy as ships, but afford valuable data as to the coefficient of friction of steel on steel under severe pressures, such as must obtain at the point of contact of the tire with the rail. Captain Galton's experiments show that the coefficient varies widely with the speed and other elements, being sometimes as little as 0·05. With dry rails the adhesion of the driving wheels indicates a coefficient of about 0·20 to 0·25, and with wet rails 0·15 to 0·20. Probably with "greasy" rails it would not exceed the 0·10 arrived at by Morin fifty years ago as an average.

Calculations of the stresses on the piers have been made upon the hypothesis that coefficients of 0·10 and 0·25 obtain on different bedplates at the same moment in the manner most unfavorable to the structure. A variety of other assumptions and test calculations have been made. As a final result, we are of opinion that the maximum stress on the masonry of the main piers will be something between 9 tons and 12 tons per square foot. To attempt a closer approximation would only serve to advertise our incapacity to appreciate the complex character of the problem and the un-
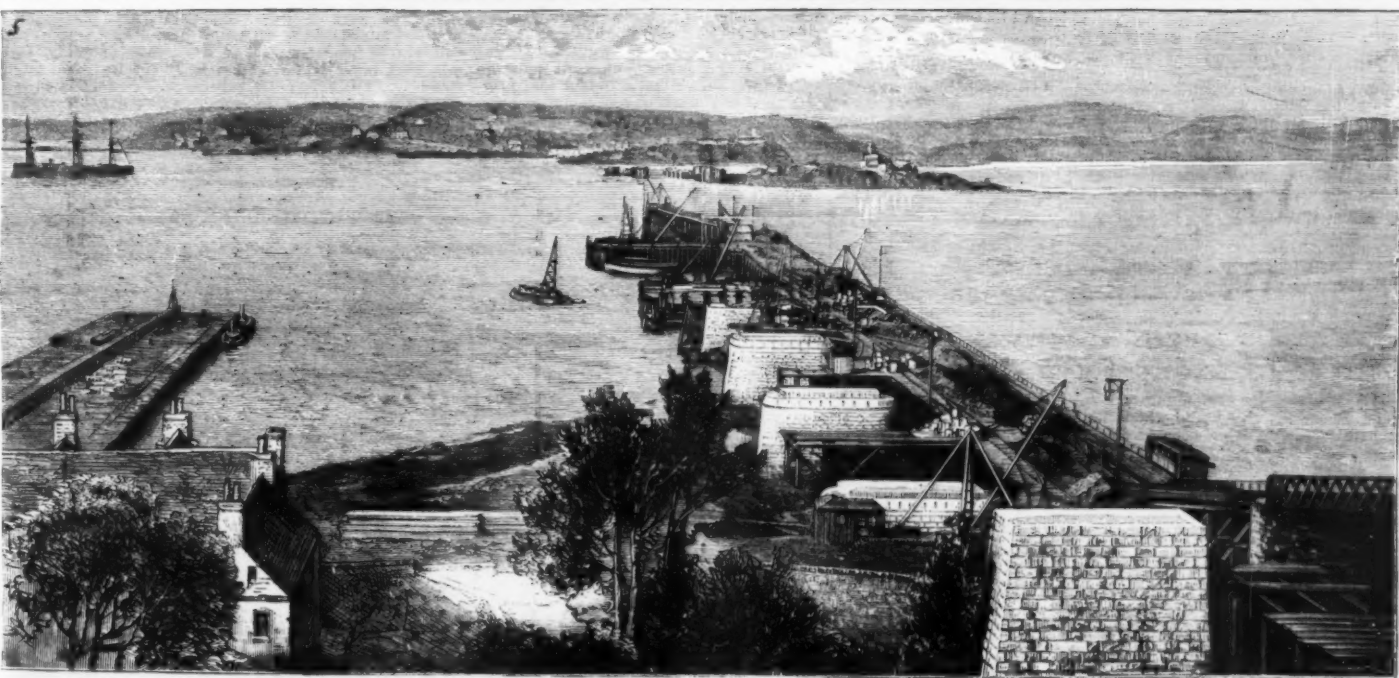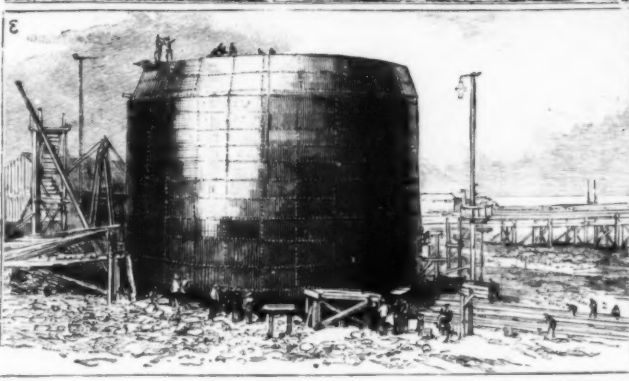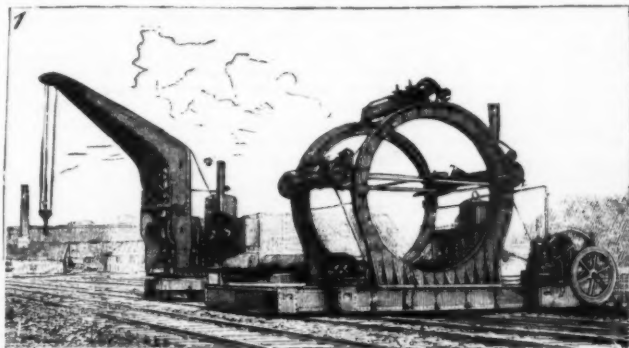
1. Machinery for Drilling the Steel Tubes of which the Bridge is to be Constructed.—2. View from the North Shore, looking South.—3. A Caisson on Launchway, at Low Water.—4. Launch of a Caisson.—5. View from the South Shore, Looking North.

THE WORKS AT THE FORTH BRIDGE RAILWAY, N. B.

certainty of some of the data. So far as compression is concerned, our concrete, which has a crushing resistance of 50 tons per square foot, would thus give a factor of safety of at least four. The solid Arbroath stone piers are, of course, of far greater strength both as regards compression and the shearing and possibly tensile stresses to which the piers may be subject under the extreme hypotheses made as to force and distribution of wind.

Very valuable data as to the ability of a massive rubble pier in cement to resist a heavy lateral force were afforded by the experimental arch of 124 ft. span and 7 ft. rise built in Paris some fifteen years ago. The thrust of the arch was about 1,400 tons, and treating the abutment as an elastic solid, the stress upon the masonry would range from 14·7 tons compression to 8·7 tons tension per square foot. To ascertain the ability of cement concrete to resist heavy shearing and tensile forces, I tested a number of concrete beams having different proportions of cement. Such concrete as that used at the Forth developed a tensile strength under transverse stress of about 10 tons to 12 tons per square foot, so that it was from no inherent weakness in the concrete that masonry was substituted for it in the 36 ft. upper length of the main piers. Our reason for its adoption was that we believed by using natural flat-bedded Arbroath stone set in two to one cement mortar, with both horizontal and vertical bond, we made certain of obtaining practically a monolith, while with concrete, however careful the inspection, there might be cleavage planes of perhaps dangerous extent in places. The special stresses on the piers arising from the cantilever system of construction have received, as I have already said, our most close consideration, and we doubt not that the desired factor of safety of four will be obtained as regards all shearing, tensile, and compressive stresses to which the masonry may be conceived to be liable under any reasonable hypothesis which can be framed.

Happily, we are relieved from all anxiety as to the foundations, since the piers rest either on rock or on a bowlder clay, which for all practical purposes is as hard as rock. It may be mentioned, however, that the heaviest load at the base of any of the 70 ft. diameter caissons, including the tilting action of a 56 lb. per square foot wind, is about 24,000 tons, or at the average rate of a little over 6 tons per square foot, deducting nothing for the water displaced by the pier.

(To be continued.)

THE FORTH RAILWAY BRIDGE.

THE completion of this gigantic engineering work will be of considerable advantage to the transit of passengers and merchandise along the east coast of Scotland, as hitherto the metropolis has been cut off from communication with Fifeshire by the wide inlet of the Firth of Forth.

The work is being carried on at three points simultaneously, namely, at South Queensferry, at North Queensferry, and in the island of Inchgarvie, which lies between these points.

The chief workshops and foundries of the contractors, Messrs. Tancred, Arrol, and Co., are situated at South Queensferry. These works cover an area of many acres, and are so complete and substantial that it is difficult to realize the fact that they are the mere scaffolding of a much vaster undertaking. Lines of railway have been laid down all over the ground, and on these lines large traveling cranes and powerful drilling machines have been erected. In one of the sheds, the large caissons for the piers on Inchgarvie have been built up.

One of these caissons was successfully launched about three months ago from the building yard at the foot of Newhall's Brae. It was 70 feet in diameter at the base, and was when launched erected to a height of about forty feet, weighing some 300 tons.

The island of Inchgarvie lies in mid-channel, and is surrounded by deep water. On it rest the four main piers of the center cantilever of the bridge. The highest point of the island is covered by a ruined castle, some 400 years old, built by the Dundases of Dundas Castle. At Inchgarvie a wrought-iron landing stage has been completed, and powerful engines, air compressors, and hydraulic pumping machines have been erected.

The construction of the bridge gives employment to 1,400 or 1,500 men. The whole of the works on both banks of the Firth and on Inchgarvie are lit up with the electric light.

The whole of the steel of which the bridge is constructed is being worked at South Queensferry, where spacious sheds have been erected and filled with machinery for its manipulation.

There is a hydraulic accumulator house, by which water at high pressure is supplied all over the works to drive the various hydraulic machines.

As regards the progress of the work, the solid granite masonry of several of the viaduct piers has been completed for the reception of the iron girders; and both at North Queensferry and at Inchgarvie the excavations have made satisfactory progress.

Our engravings are from photographs by Mr. Evelyn J. Carey, Assistant Engineer, Forth Bridge Works.—*London Graphic.*

A BALLOON-STEERING EXPERIMENT.

M. HERVÉ MANGON has communicated to the French Academy of Sciences a report in which he states that a navigable balloon has at length been perfected by a captain of engineers named Renard. According to several Parisian journals, a successful public trial of the new balloon was made last week, in the presence of a large concourse of spectators. Captain Renard, it is said, has, for several years past, been prosecuting, in connection with Captain Krebs, experiments in a large inclosure in the wood of Meudon, assigned to them by the French military authorities. The difficulty was to obtain a motive force in the car of the balloon, the apparatus of which should not be too ponderous for the sustaining power of the balloon itself. If such locomotive could be safely carried by the balloon, these projectors believed it would be comparatively easy to steer it against the wind. Captain Renard discarded the idea of a steam engine, and found, it is alleged, the dynamic agent which he sought in electricity, with an apparatus of accumulators, by the force stored in which an engine of ten-horse power could be propelled during several hours. Under these conditions an ascent was made at a recent date. The balloon rose from Meudon and proceeded to Villebon, when, to the astonishment of those watching its progress, it described a semicircle and returned, notwithstanding the apparent opposition of a slight breeze, to the place whence it came. The trial was repeated, with similar results, the aeronaut subsequently declaring that the points where the

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balloon should halt, and return to its place of departure, had been fixed upon with precision beforehand.

Our illustration shows the scene in the park at Meudon, with the building of the "Etablissement d'Aerostation Militaire," and the balloon near enough to the ground for spectators to see its form and that of the car, with the screw propeller attached to its stern end. The balloon is of a long oval shape, pointed at both ends, and holding the usual supply of gas. Below was a net containing, in addition to the officer who attended the valve and the one who steered, certain electric accumulators, which supplied a motor, employed to set in action the screw propeller, by which the balloon, so far as we can understand, is not only driven in space, but also to some extent guided in the same way that a ship is directed in its true course by means of a rudder. It is said that £24,000 have been spent by the French War Office in these experiments; but during the past forty years many similar inventions have been tried, and have resulted
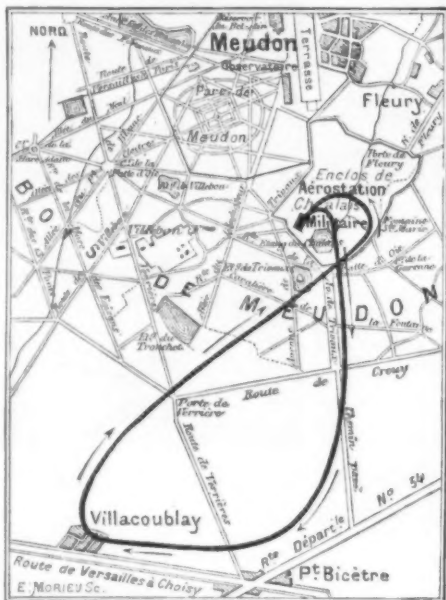
MAP SHOWING THE VOYAGE OF THE BALLOON

in failure. There is really no analogy, in the balance of mechanical forces, between the position of a buoyant machine, entirely surrounded by the air in which it hovers, and that of a vessel floating on the surface of the water.—*Illustrated London News.*

RENARD AND KREBS' ELECTRIC BALLOON.

THE problem of steering balloons, which was for a long time regarded as visionary, has made great progress in recent years, and may now be considered as solved. Captains Renard and Krebs have the honor of being the first to successfully accomplish this, and therefore merit the gratitude of their contemporaries. But, of whatever interest be their work, we must not forget those who have preceded them, and shown them the path that they should follow. Before speaking of the memorable ascension of Aug. 9, 1884, we think it indispensable to trace the history of the steering of elongated balloons provided with screw propellers.

It was in 1852, thirty-two years ago, that the way was opened by our great engineer Henri Giffard. It was then that a true aerial ship, of elongated form, and provided with a screw and rudder, was for the first time seen to rise into space. This ship was 44 meters in length, and its equatorial diameter was 12 meters. The balloon was surrounded on every side, except beneath and at the ends, with a netting whose extremities united on a stiff wooden bar. At the extremity of this latter there was a triangular sail, movable around a rotary axis, which served as a rudder and keel. At six meters beneath the bar a steam engine mounted upon a wooden frame was suspended along with its accessories. The propeller, which consisted of two large blades, was 3·4 meters in diameter, and made 110 revolutions per minute.

Empty, the engine and boiler weighed 150 kilogrammes. Provided with water and coal for starting, they weighed 210 kilogrammes; the accessories to the engine and the supply of coal and wood weighed 420 kilogrammes more.

Henri Giffard had then no financial resources. He agreed to make his first ascent on a certain day at the Paris Hippodrome. On the 24th of September, 1852, the balloon was inflated with illuminating gas, and Giffard ascended all alone to the sharp whistling of his engine. The wind was very strong that day, and the inventor could not think of stemming the aerial current, but the different maneuvers were effected with the completest success. The action of the rudder made itself felt very plainly, thus proving that the aerial ship had a very appreciable velocity. At an altitude of 1,500 meters, Giffard met slower currents, and found it possible at moments to keep head to the wind. The future inventor of the injector had performed an experiment which caused him to be called by a celebrated writer of the time "the Fulton of aerial navigation."

Giffard's efforts, which were renewed by him in 1855, were followed by the fine experiment executed by Mr. Dupuy de Lome, on the 2d of February, 1872. This gentleman's balloon was 36 meters in length, and about 15 in equatorial diameter. It had a capacity of 3,500 cubic meters, and was inflated with pure hydrogen. The propelling screw was 6 meters in diameter, and was actuated by seven men in the car. The motor was assuredly insufficient, but De Lome, under the influence of his screw, nevertheless obtained an appreciable deviation from the line of the wind, and ascertained that his aerial ship had a velocity 8 kilometers per hour.

What had been wanting up to this time was a motor that was truly adapted to balloons—a light motor that did not necessitate the use of fire, and that should lose no weight during its operation. As long ago as 1881 Mr. Gaston Tissandier made known the result of his studies and experiments upon the "Applications of Electricity to Aerial Navigation." In a note presented to the Academy Aug. 1, 1881, he expresses himself thus:

"The recent improvements made in dynamo-electric machines have given me the idea of employing them for the directing of balloons, concurrently with secondary batteries, which, although of relatively light weight, store up a large amount of energy.

"Such a motor, connected with a propelling screw, offers advantages over all others, from an aerostatic standpoint. It operates without any fire, and thus prevents all danger from that element under a mass of hydrogen. It has a constant weight, and does not give out products of combustion which continuously unballast the balloon and tend to make it rise in the air. It is easily set running by the simple contact of a commutator.

"I have had a small elongated balloon made, which terminates in two points and is 3·5 meters in length by 1·3 meters in diameter at the center. This balloon has a capacity of about 2,200 liters. Inflated with pure hydrogen, it has an excess of ascensional power of two kilogrammes.

"The balloon is provided with a small Siemens dynamo-machine weighing 220 grammes, whose shaft is connected, through the intermedium of a gearing, with a very light, two-bladed helix, 0·4 meter in diameter. This little motor is fixed to the lower part of the balloon, with a secondary battery weighing 1·8 kilogrammes. The screw, under such circumstances, revolves at the rate of 6½ revolutions per second, acts as a propeller, and gives the balloon in still air a velocity of 1 meter per second for more than forty minutes. With two secondary batteries mounted for tension, and weighing 500 grains each, I can gear with the motor a screw, 0·6 meter in diameter, that will give the balloon a velocity of about 2 meters per second for about ten minutes. With three elements the velocity reaches 3 meters. I have renewed the experiments a large number of times."

It will be remembered that this model was exhibited while the Exhibition of Electricity in 1881 lasted. After these first experiments Mr. Tissandier had constructed at the Siemens works a light dynamo machine, and soon devised a new style of bichromate of potash pile, which gave him a powerful and light generator of electricity that was more favorable than accumulators of the same weight. He then resolved to construct a screw-propelled electric balloon designed to work in the free air. M. Alb. Tissandier, his brother, joined efforts with him, and it was at the expense and with the collaboration of the two in common that the first trial of aerial navigation by electricity was made last October. The Tissandier balloon was 28 meters in length and 9·2 in diameter at the center. As we have already given an illustrated description of it,* we need not here repeat it,

* SCIENTIFIC AMERICAN SUPPLEMENT, No. 416.
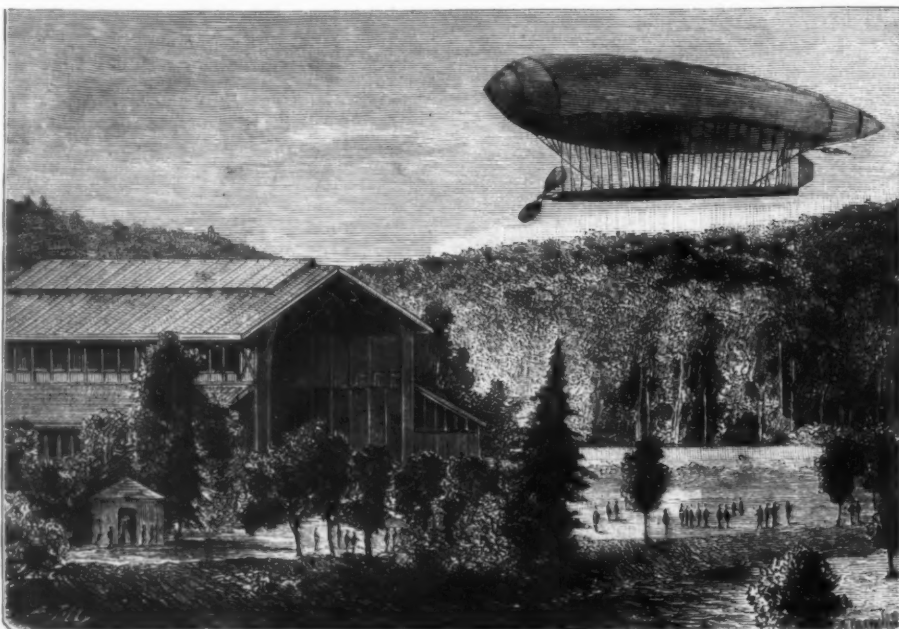
RENARD & KREBS' BALLOON STEERED BY ELECTRICITY, AT MEUDON, NEAR PARIS.

but may pass on to the remarkable experiments of Messrs. Renard and Krebs.

The balloon constructed by these gentlemen is 50·42 meters in length and 8·4 in diameter, and has a capacity of 1,864 cubic meters.

The motor is constructed in such a way as to make it possible to develop upon the shaft, 8·5 H.P., representing for the current at the entrance terminals 12 H.P. It transmits its motion to the shaft of the screw through the intermedium of a pinion that gears with a large wheel.

The pile is divided into four sections that are capable of being grouped for surface or tension in three different ways. Its weight is 19·35 kilogrammes.

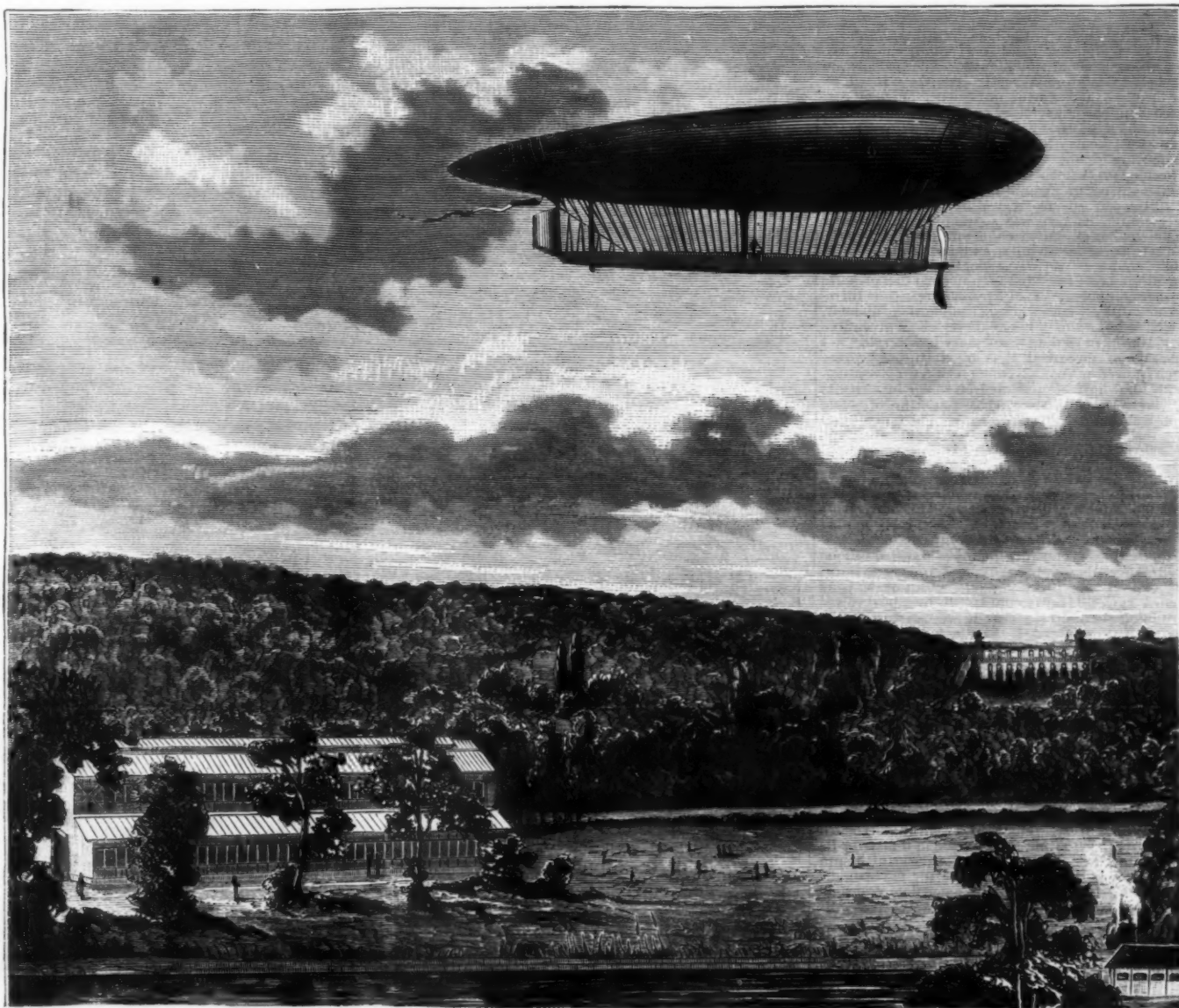RENARD & KREBS' BALLOON STEERED BY ELECTRICITY, AT MEUDON, NEAR PARIS.

On August 9, 1884, at 4 o'clock in the afternoon, the air being nearly quiet, the balloon, being freed and possessing a very slight ascensional power, arose slowly in the air. The machine was set in motion, and under its impulsion the balloon soon quickened its pace, faithfully obeying the least indication of the rudder.

The first direction taken was from north to south, over the plateau from Choisy to Versailles. So as not to stand over the trees, however, the direction was changed, and the fore end of the balloon pointed toward Versailles. Over Villacoublay, about 4 kilometers from Chalais, the aeronauts, entirely satisfied with the behavior of the balloon thus far, decided to retrace their steps, and attempt to descend at Chalais, notwithstanding the slight space that existed free from trees. The balloon made its half turn to the right by a very slight angle (about 11°) given to the rudder. The diameter of the circle described was about 300 meters. The dome of the Invalides, taken as the directing point, then left Chalais a little to the left of the route. Reaching the level of this point, the balloon changed its direction to the left with as much ease as it did before, and was soon hovering at a height of 300 meters over its starting point.

Its tendency to descend at this moment was shown the more by a maneuver of the valve. During this time it became necessary to run backward and forward several times, in order to bring the balloon over the spot chosen for anchorage. At a distance of 80 meters above the ground the rope was thrown out, and being seized by men, the balloon was drawn down to the very field from whence it had started.

In our engraving the balloon is shown in profile, at the moment when it is beginning to be set in motion. The screw is in front, and, in revolving, it drives the air laterally over the two sides of the large, elongated car, 33 meters in length. We are informed that the dynamo employed was constructed by Mr. Gramme. The generator of electricity consists of a battery of piles whose nature has not been made known by Captain Renard. The travelers stand in the center of the car, and one of them runs the machine while the other governs the rudder. — *L'Illustration.*

In addition to the foregoing engraving we also give sketches from *La Nature* and from the *London News.*

AERIAL NAVIGATION.

THE world is bid to understand that August 9, 1884, is to be "for ever memorable in the annals of discovery." Such was the announcement made the other day by M. Hervé Mangon, in presenting a report to the French Academy of Sciences concerning a balloon voyage conducted by Captain Renard and Captain Krebs, the former being the director of the Balloon Works at Meudon, and the latter his assistant. The voyage was not a long one, but it was remarkable as beginning and ending at the same spot. The balloon went from Meudon, and it returned thither, the point reached in going out being the Hermitage of Villebon, about seven miles distant. On the outward trip the wind had a rate of 18 ft. per second against the balloon, but the aerial ship was propelled in the teeth of the current by the action of a screw, rotated by means of certain electric accumulators, capable—it is stated—of supplying the power of ten horses for the space of four hours. The balloon was elliptical in form, having in its car the electrical apparatus. A rudder projecting outside, like that of a boat, sufficed to steer the machine. Captain Renard attended to the propeller, while his companion took the part of steersman. The time occupied in going out and getting home again was about forty minutes. The altitude maintained is reckoned at 180 ft, and the balloon went straight for Villebon, as intended beforehand. On reaching the goal Captain Krebs waved a flag as a signal that he was going to turn, and astonished everybody who was looking on by forthwith doing so. Describing a curve of 300 meters radius, the balloon sailed back to Meudon, where it quietly descended, the machine being "eased, reversed, stopped," and hauled down to earth by a rope, touching the ground without the slightest shock. Such, in substance, is the story of this adventure; but it is stated that certain technical details have been kept secret by the inventors, except from the Minister of War. Captain Renard fully believes that he has solved the problem of aerial navigation, and he looks forward to the time when the balloon will become "a formidable engine of war." But there are doubters in some quarters. Mr. Henry Coxwell signifies that he has on certain occasions managed to go out and come back again in a balloon; but he has accomplished the feat solely by taking advantage of conflicting currents, and he seems to conceive that something of the kind occurred at Meudon. Colonel Beaumont, having considerable experience in military ballooning, has been "interviewed," on the subject, and being asked what he thought of the French achievement, replied, "What do I think of it? Nothing!" Admitting that Captain Renard had once steered his balloon for a short distance, "let him do it again," said the English Colonel. The enormous power necessary to navigate a balloon is clearly apprehended by Colonel Beaumont, as also by Mr. Coxwell, and those who know most of aeronautics are least likely to be captivated by the French report.

History is said to repeat itself; but we are not going to be quite so skeptical as to suggest that the Meudon voyage is to take rank with the still more wonderful affair narrated in a Paris journal in the year 1857. It was then announced that M. Gavarni, an artist, after studying the subject for six

RENARD & KREBS' ELECTRIC STEERING BALLOON, LATELY TRIED NEAR PARIS.

years, had succeeded in completing a machine at a cost of 300,000 f., by means of which he hoped to be able to sail in the air in all directions. Proof that he could do this had already been given. His machine consisted of two spherical balloons fastened together. "The propelling power," said the record, "is obtained by a peculiar sort of screw, reaching as far as the car, which is provided with a rudder of whalebone." Preparations for the voyage were made "in as private a manner as possible," and only four persons were allowed to be in the secret. These four were Le Comte de Pleuvier; M. Edward Migeon, professor of the physical and mathematical sciences; M. Jules Falconer, an aeronaut; and M. Henri Page. These, with M. Gavarni, made the ascent from the park of the Comte de Pleuvier. After rising to a great height, M. Gavarni said to his companions, "We have the wind against us; now or never is the moment to try my screw. Gentlemen, I mean to steer for Algiers, where Marshal Gaudon impatiently looks out for our arrival." The Loire was passed at twelve o'clock. At two o'clock Gavarni saw the sea. In half an hour more Nismes was passed, leaving Marseilles on the left and Toulon on the right. Ultimately the double balloon descended about a mile from Algiers, where a cordial reception was given to the party by "His Excellency Marshal Gaudon." The return voyage was soon afterward accomplished, and a safe descent was effected in the park of the Comte de Pleuvier. This was published, with an abundant garniture of details, and probably a good many people believed the story. The narrative of Meudon has the merit of being more modest, and the voyage is a very brief one. But the account is received on this side the Channel with a considerable degree of caution. The numerous schemes of aerial navigation which have come to nothing, have made the British public slow to believe in aeronautic triumphs. About two years after the alleged voyage to Algiers and back, the *Times* devoted nearly two columns of large type to a letter signed "Vespertilio," the subject being entitled "How to Navigate the Air." The writer wound up his dissertation by saying, "The problem of aerial navigation will be easily solved whenever the progress of science shall place us in command of a motive power considerably lighter, in proportion to its capacities, than the steam engine, and not till then."

This conclusion has much to recommend it, and yet it may be doubted whether the problem will be found easy of solution, even when the world has the benefit of a motor "considerably lighter" in proportion to its power than the steam engine. The idea of navigating a balloon is easily conceived, but there are difficulties in the way which are generally underrated. As for the Meudon experiment, it certainly requires further explanation. The distance traversed was fourteen miles, and the time occupied about forty minutes. This alone would indicate a power of propulsion in the machinery of the balloon equal to a speed of 21 miles per hour. But the outward journey was made against the wind, which had a velocity of about 12 miles per hour. We may reckon that the outward journey would take half an hour. This would correspond to a velocity of 14 miles per hour, irrespective of the wind. But in order to counteract the effect of the aerial current, we must add 12 miles per hour to the propelling power exercised on the balloon, thus making a total of 26 miles per hour. On the return the wind would be favorable, thus adding 12 miles per hour to the self-created velocity of the balloon, and making a total of 38 miles per hour. The seven miles homeward would thus be accomplished in 11 minutes, making 41 minutes in all, the reported time being "about 40 minutes." The calculation we have made is therefore sufficiently accurate. It will be seen that if the observations made on the occasion were correct, the propelling power exercised by the screw must have been such that in a dead calm the balloon would travel at the rate of 26 miles per hour. But this is equivalent to a brisk gale with a pressure of more than 3 lb. per square foot. The elongated form of the balloon would diminish the resistance to be encountered; yet this would still be very considerable. Granting that the performance was really as it appears, the speed proper to the balloon was extraordinary. Even if there were no wind at all, the machine must have driven the balloon at a rate exceeding 20 miles an hour; and this of itself is enough to excite surprise. Such a velocity is the milder form of the brisk gale, and is equivalent to a pressure of 2 lb. on the square foot. The French narrative is therefore very wonderful, if, indeed, there is no mistake about it.

What we may term the "inherent velocity" given to a balloon by means of propelling machinery is of service, not only for the sake of the speed thus obtained, but because without such power of motion there can be no steering. Some curious ideas have been mooted on this point. It has been said that anybody can steer a balloon in the direction of the wind, and that nobody can steer a balloon in a calm. The truth is that a balloon, *per se*, knows nothing about the wind, and is always in a calm. When a balloon comes to be propelled by some internal motor, it encounters atmospheric resistance, solely due to its own motion. Having motion of its own, it can then be steered. But while it is thus traveling in the region of the air, it is subject to all the movements of the atmosphere, and its geographical course is a combination of its own motion and that of the current in which it travels. If a dead calm prevails, then the propelled balloon takes its course over the earth in exact accordance with its own inherent speed and direction. The effect of the wind on a propelled balloon is fairly illustrated by a boat rowed across a running stream, especially if we can conceive of the boat as entirely submerged, like a torpedo propelled under water. The motion produced by the wind in respect to a balloon is that of drifting, somewhat as a ship may be affected in its course by tides and currents. Propelling power would enable a balloon more or less to maintain its own course, as directed to any particular part of the earth. That a balloon may be propelled at a low velocity, and steered accordingly, is conceivable; but an artificial speed of twenty or thirty miles an hour is more than we can at present understand. Granting that any such speed has been obtained, the difficulties in the way of a substantial addition to that velocity appear insuperable. If ever aerial navigation is to be accomplished in a practical form, it is scarcely likely that the balloon will have much to do with it. The bag of silk inflated with gas is far too bulky and flimsy for the work that has to be done. A motor so powerful in proportion to its weight as to be available for navigating a balloon would be better employed in connection with some aerial machine unencumbered with gas.—*The Engineer.*

MANAGEMENT IN LIFE INSURANCE.

Mr. Walter C. Wright desires us to say that in his article on this subject in SUPPLEMENT 455 the net rate of interest earned by the John Hancock Life Insurance Co. should have been given as 5·19 instead of 3·65, and the rank should be 17 instead of 26.
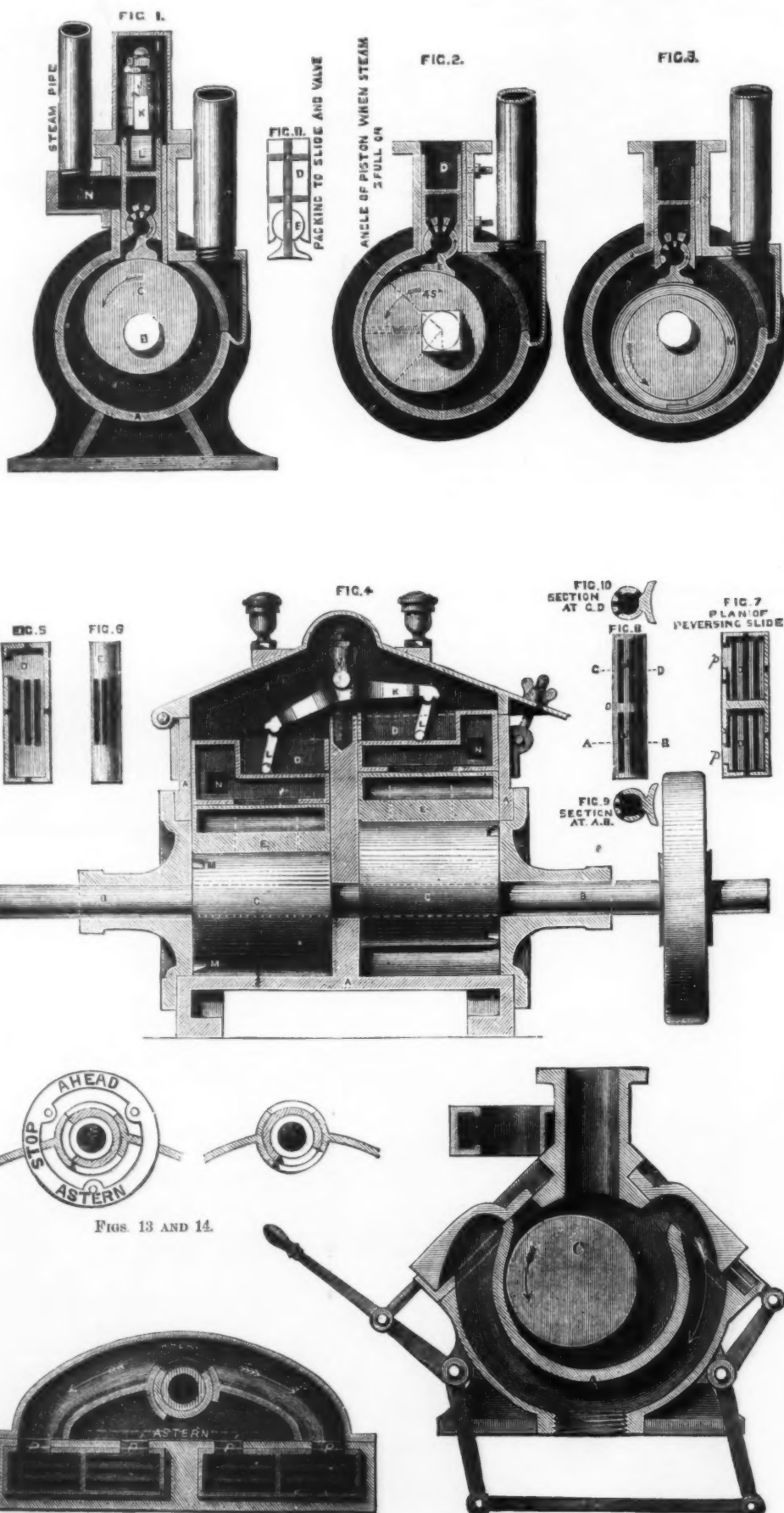
IMPROVED ROTARY ENGINE.

THE chief difficulty hitherto with this type of engine has been to obtain a perfectly steam-tight abutment, and as the use of steam or springs for this purpose causes a serious loss of power, inasmuch as they give out their power on the up stroke of the piston, and thereby act as a brake, it became a problem how to maintain a steam-tight abutment with the least possible friction.

This engine, patented by Mr. John Pinchbeck, of London, goes far toward satisfying this problem, as in it a mechanical connection is established between the abutments of two cylinders in such a manner as to give a minimum of friction, and yet permit a large area of the abutment being in contact with the piston.

This is shown in Figs. 1, 2, and 3, which are cross sections of the cylinder, showing three different positions of the same piston during one-half revolution in the cylinder. In Fig. 1 the steam ports are about to open, in Fig. 2 they are fully opened, and in Fig. 3 they are closed at half a revolution of the piston. Fig 1 also shows the abutment, E, turning in the direction of the small arrow; in Fig. 2 the abutment is shown turning in the opposite direction, and preparing to cut off steam, which takes place when the piston has reached its downward position (as in Fig. 3); expansion then begins, and continues till it has reached the exhaust, when the steam passes away. Steam is full on when the angle 45° is reached, and remains so until the angle of 135°, when closing begins, and is completed at 180°. As will be seen, the opening and closing of the ports which admit steam is effected by the lateral rocking action imparted to the abutment by the rotation of the piston itself, thus dispensing with any eccentric or slide-valve. Close contact between the abutments and pistons is maintained by the following mechanical means: The hollow radial slides, D D, are permanently open to the admission of steam by means of the ports, N N, Figs. 2, 4, 5, and 7. These are maintained steam-tight by suitable metallic spring-packing pieces (see Fig. 11), the faces of which are adjusted to the faces of the slide-box by set screws, Fig. 2. A longitudinal section of the cylinder is given at Fig 4, showing the position of the pistons at the top and bottom, the cylinder being divided by a partition to form

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 10 SECTION AT C.D.

FIG. 8.

FIG. 7. PLAN OF REVERSING SLIDE.

FIG. 9 SECTION AT A.B.

FIGS. 13 AND 14.

FIG. 12.

FIG. 15.

IMPROVED ROTARY ENGINE.

two cylinders, and the abutments so connected as to balance each other.

The slides, D D, allow the abutments to rock laterally, and these are held down by the distance pieces, L L, these in turn being held down by the rocking lever, K, working on the center, J, the pressure being adjusted by lock-nuts. A mechanical attachment is thus established between the two rocking abutments, which maintains absolute contact between them and the pistons without any variation in the pressure of that contact, whatever the position of the pistons. But an element of disorder arises, inasmuch as the length from the lower centers of the distance pieces, L L, to the centers of the cylinders is constantly changing by reason of the versed sine of the angle the rocking abutments make with a vertical line, this distance being longest when the pistons are in the position shown at Figs. 1 and 3, and shortest when in the position shown in Fig. 2. This variation is compensated for by the introduction of the distance pieces, L L, which are made to assume the same angles as the abutments, but at exactly opposite periods, they being vertical when the abutments are at their greatest angle, and vice versa. From this it will be readily seen that a constant and uniform pressure is maintained between the abutments and pistons at all points of their revolution. The whole of the working portions of the engine are protected from dust by the cover, I, which is hinged and fastened by a thumb-nut, so as to be readily opened either for oiling, etc., or the adjustment of the nuts bearing on the rocking-lever, K, and on the center-piece, J. An efficient lubrication is maintained by lubricators, which drop oil into the distance pieces, and into wells on the top of the slides, from whence, by means of the oil-holes, Fig. 5, the faces of the slides are lubricated. The pistons are not keyed on to the shaft, which at that part is square, but have a certain amount of play so as to enable the set-screws to bring their faces into contact with the inside of the cylinders, as shown in Fig. 2 by the dotted lines, it being understood that for a width of about three-quarters of an inch the curves of the piston is the same curve as that of the cylinders. To insure a steam-tight joint between the piston ends and the cylinder covers a packing-ring is provided on each piston eccentric with the cover, in order that it may sweep over the entire surface and thus prevent its wearing in grooves; this is shown by M, Fig. 3. From the foregoing description it will be seen that a rigid mechanical connection is maintained by means of the lever, K, between the rocking valves, without any undue pressure being exerted on the pistons other than what is absolutely necessary to keep a steam-tight joint, and which Mr. Pinchbeck claims as a great improvement on any other rotary engine, and also that in his engine the wearing parts are so constructed as to wear steam-tight the longer they run. Messrs. Waygood & Co., of Newington Iron Works, Falmouth Road, Borough, constructed an 8 in. cylinder engine of this description, which, when tested with a suitable dynamometer, indicated about 8 H.P. A simple modification of the engine, as above described, enables it to work as a reversing engine. Instead of a single set of ports in the slides and rocking valves a second set is introduced, and these are divided from the first by a partition, as shown in Figs. 7, 8, 9, and 10. When running forward steam enters by the ports, A B, Figs 8 and 9, and when running backward by the ports, C D, Figs. 8 and 10, the admission into the ports, P P, being regulated by a suitable slide, so that either the one or the other may be opened alternately; the exhaust ports are also duplicated.

The first arrangement is given in Figs. 12, 13, and 14. Steam, as shown in Fig. 12, is admitted through the plug, and finds its way into the cylinder through the ports, P P. By one half-turn of the plug the opening is reversed, as in Fig. 14, when the action is reversed by steam entering through the ports, p and p'.
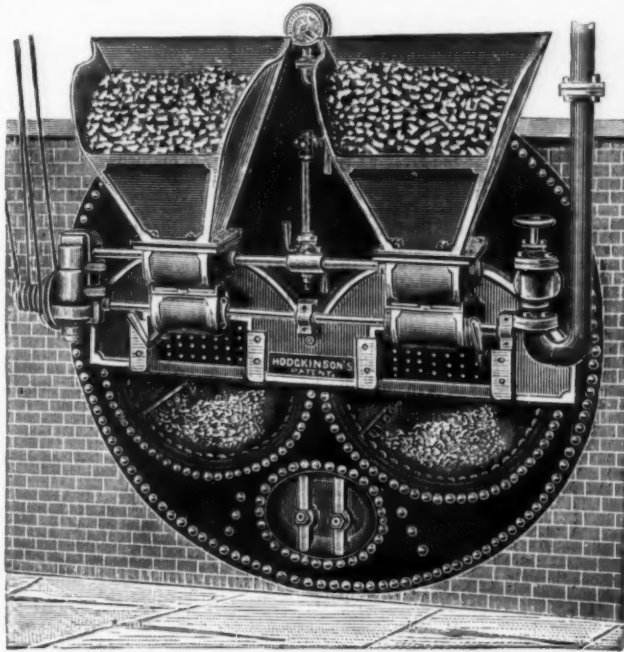
Fig. 15 shows the method adopted for the alternate opening and closing of the opposite exhaust ports. In this view the engine is supposed to be going ahead, steam being admitted as shown by the arrows in Fig. 12.

From its simplicity, the small number of its working parts, and the general correctness of its principles of construction, we think this engine will commend itself to marine engineers.—*The Marine Engineer.*

IMPROVED MECHANICAL STOKER.

MR. HODGKINSON, of the Ordsal Machine Works, Salford, claims for his invention that it meets all the demands likely to be made on it. The general arrangement of the machine which we illustrate is as follows: A large hopper for the reception of the coal to be fed into the bars stands well up, its top being about level with the top of the boiler, or, if necessary, higher still; at its mouth is a slowly revolving rose, which makes about three revolutions in two minutes, and which keeps the coal agitated, and feeds it uniformly into the lower drum. The interior of this lower drum is fitted with a revolving boss, on the periphery of which two fans or webs are cast, the duty of which is to send the coal on to the bars; these fans or webs are curved convexly to the direction of their revolutions. The exact curve has been arrived at by experiment, and is so made to scatter the coals along the sides as well as the center of the furnace. A fast running shaft, with a series of graduated pulleys, passes through this boss, which can be driven as occasion demands at any speed from 100 to 500 or 600 per minute, 200 having been found to be the best speed, as at that it spreads the coal well without knocking it into dust. The shafts are driven from the pulleys at the side of the machine; the arrangement of speeds—one very slow, the other very quick—being effected by means of worm wheels on a small vertical shaft at the side. Below the feeding drum a fire door is fitted for the convenience of cleaning fires, examining the furnace, or, if necessary, for allowing of hand stoking. It will be readily understood that the coal is sent into the fire like hail; that a perfectly level fire is maintained, as thick or as thin as is desirable; that in consequence of the "hailing" of the coal the fuel bursts into combustion almost before it touches the fire, and that smoke is as a result to a remarkable extent consumed; furthermore, that as the firing is theoretically good, being perfectly level and thin, and that coal of a very inferior order may be used, a high degree of economy is assured. The whole machine is hung by means of brackets and T-bolts from the top of the boiler, and so the necessity to drill holes in the front plate is obviated, as well as the evil of having a heavy piece of mechanism with full hoppers of coal hanging from a plate already fully loaded, with the steam pressure on the other side of it. We have seen a couple of machines fitted to and working on a large Lancashire boiler in the works of Messrs. Bamber Bros., Bolton. The boiler is 7 ft. in diameter by 30 ft. long, and supplies steam to two engines, one of 18 in. diameter cylinder, the other of 24 in. cylinder, both strokes 4 ft. The safety valves are loaded to 75 lb. pressure, but by an inge-

nious contrivance the "stoker" is set so that it maintains steam just below the blow-off point, in this way: The main steam pipe is furnished with a small pipe, ¾ in. or thereabout, which is led into a valve box at a convenient place. This valve-box is fitted with a valve, which has a long spindle passing through a stuffing-box, and attached to the end of a balanced bell crank. A wire is fitted to the bell crank, which moves the bell fork for throwing the driving belt of the "stoker" on to the fast or loose pulley, and the same bell crank is also attached to the damper in the chimney. As soon as the set pressure is exceeded, the valve lifts, throws the bell crank over, which puts the driving belt for the stoker on to the loose pulley, and consequently stops the firing, while it at the same time puts the damper into the chimney. As soon as the steam drops to the desired pressure, the valve falls again, and by means of its bell crank pulls the damper out of the chimney, and starts the "stoker" again. We saw this operation being done automatically every few minutes; in fact, every time the weight on the engines was altered by the addition to or withdrawal from work of any machine in the factory, or by the stoppage of either engine, this arrangement acted as a governor. The fire-bars of this particular boiler are revolving bars, but, unlike others, they run out instead of in, and so carry with them the unconsumed ashes, refuse, or clinker, which are deposited within a handsome brass-mounted fender in front of the boiler. We were informed by a very intelligent fireman who was engaged in looking after this boiler, that since the adoption of the Hodgkinson stoker the consumption of coal, under precisely similar circumstances, had fallen from over 20 tons per week to under 13. Ignition certainly seemed to be instantaneous, and combustion all but, if not quite, perfect; the fire was as level as a table, and from end to end one glowing sheet of flame. By a touch the feed could be instantly increased or diminished or altogether stopped. The great benefit of such a stoker as this is that more steam can be raised with greater certainty and less work and trouble, at a saving of from 15 to 25 per cent., while a very much inferior class of coal can be used. The changing of speeds of feeding can be done in a moment, and the quantity of coal may be varied from 6 or 8 tons to 35 tons per boiler per week of fifty-four hours. We have seen the stoker working with the ordinary fire-bars, with the revolving bars, and with Hodgkinson's patent rocking bars, and in all cases with satisfaction, and this is a point in its favor, as most other machines without a special grate bar are useless. This stoker has been tried at sea, and with highly satisfactory results, it being in successful use on, for instance, the State Line steamer State of Nevada.—*The Engineer.*

STEEL RAILROAD TIES.

MR. F. W. WEBB, Chief Mechanical Engineer, London & Northwestern Railway, England, says they have laid over 20,000 sleepers in steel, and are now making a further quantity for laying next year.

The accompanying cut shows this form of permanent way.* The 84 lb. bull-headed rail is gripped by two half
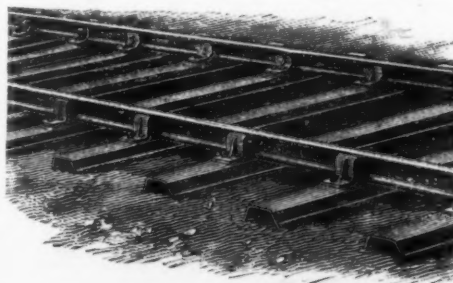
STEEL RAILROAD TIES.

chairs, stamped out of a steel strip and riveted to the tie, a sheet of creosoted paper being interposed to deaden noise and vibration. A compressed wooden key is used, and is kept in place by expanding into an internal groove in the chair. Each tie weighs about 100 lb., and their cost in England is about the same as that of the usual style of soft wood tie. The *Railroad Gazette* thinks, if steel should remain at

* See also *Railroad Gazette* for April 13, 1883.

its present price, it seems probable that it will be the cheaper as well as the more durable material for ties not only in England and Germany, but in many of the Southwestern States.

THE WOLF SAFETY LAMP.

A NEW safety lamp for coal mines and other places where the atmosphere is liable to be rendered explosive by escapes of inflammable gas has been invented by Herr Wolf, of Zwickau, Saxony. This lamp is in many respects held to be an improvement on the Mueseler, or Belgian lamp, which is so highly esteemed in England and abroad. Unlike all others of its class, the Wolf lamp burns benzine, which is cheaper than vegetable oil, gives a brighter and more uniform flame, and does not deposit soot. As a consequence of this, a much finer wire gauze can be used, with greatly increased safety; and the wick, being of mineral wool, does not require cleaning or picking during a miner's shift. The lamp is fastened by a lock, which can only be opened by a magnet; and as it is not necessary to open the lamp to relight it when it has become accidentally extinguished, a further serious risk attending ordinary lamps is removed. The body of the lamp, which contains the benzine, is packed with mineral wool to prevent spilling. The flame may be raised or lowered to a limited and safe extent by means of a screw collar. The arrangement for lighting consists of a tape carrying at intervals small percussion wafers. A button operates both the upward feed of the tape (which brings a fresh percussion wafer to the point of ignition), and also the tripping of the lever, which explodes the cap. The Wolf lamp is said to burn in bad air long after others would go out; but, of course, there is a point at which it is extinguished by the preponderance of inflammable gas.

A WATER LINE APPARATUS.

A USEFUL laboratory appliance for maintaining a constant water line in an evaporating bath has been designed by Dr. Eugene Mascarenas y Hernandez, and described in the *Chronica Scientifica*, from which the accompanying illustration is taken. It is very simple and easily made, consisting of a bottle, F, filled with water, and closed by a cork through which pass two tubes, A and B, both curved at right angles. The first tube reaches nearly to the bottom of the bottle, F, while the second just enters through the cork. The other ends of these tubes are led to the vessel, M, in which a constant water line is to be maintained. So long as the water line remains constant in M, the air cannot penetrate into the bottle, F; and the siphon constituted by the tube, A, will not work. When the level of the water falls, the extremity of the tube, B, becomes unsealed, air enters by it, and water is siphoned from the bottle until the water line assumes its normal height, and seals anew the air inlet tube. In order that the apparatus may work regularly, it is necessary that the two tubes should be of equal diameter; or, preferably,
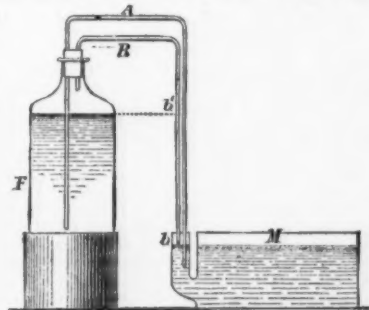
that B should be the larger. The end of this tube which dips into the liquid in M should be cut on the bevel, to facilitate the passage of air through the liquid column. b, b', which it incloses when its lower extremity is sealed. In the illustration the bottle, F, is shown on a stand, and the recipient is shown provided with an attachment for the inlet of water. The latter adds to the regularity of working; but neither is necessary for the successful use of this very simple appliance, which does not require any special support or alteration of the water bath.

MECHANICAL STOKER.

PHOSPHORIC ACID FROM SLAGS.

By Dr. C. SCHEIBLER.

THE slags obtained in Westphalia by this process contain 4½ to 8½ per cent. silica, 9 to 14 iron, chiefly in the ferrous state, 17 to 21 phosphoric acid, and 47 to 52 lime. If it is found practicable to separate the phosphoric acid in the form of calcium phosphate, and to eliminate the silica from the residue of the slag, the remainder, consisting chiefly of oxides of iron and manganese, and of lime and magnesia, will prove an excellent material for the production of manganiferous irons and for other technical purposes. The method used at Schalke and Stolberg aims at this decomposition of the slags into bisulphate and into manganiferous iron oxides. For this purpose it is necessary in the first place to convert the ferrous and manganous oxides into the corresponding ferric and manganic salts by a process of roasting, in a current of air, and thus to make them less liable to the action of acids, at the same time to destroy the iron and calcium sulphides present in the slags by oxidation. At Schalke the slags are roasted in reverberatories with a sloping double sole 9 meters in length by ¼ in breadth, which allow of a complete utilization of the heat. The consumption of coal is trifling. For roasting 1,000 kilogrammes slag there are required 100 to 130 kilogrammes of coal, and such a furnace roasts in twenty-four hours 15 to 17,500 kilogrammes of slag. The slag is finely pulverized either before or after roasting. The comminution of the greater part of the roasted slags is easily effected by treating them with steam, whereby the quicklime contained in the slags is converted into hydrated lime, which effects the mechanical disintegration of the slags into a fine powder. Portions which resist this process may be pulverized by disintegrators. The granules of steel are separated by sifting, or by means of magnets. From the finely pulverized slag the earthy silicates and the calcium phosphate are extracted by means of very dilute acids. This dilution is necessary to prevent the coagulation of the silica, so that the solutions may be easily separated from the residues by filtration or decantation. Hydrochloric acid is to be preferred, as sulphuric acid occasions inconvenience by the formation of gypsum, which envelops the particles of slag. At Schalke 1,180 to 1,250 kilos. hydrochloric acid at 30° Tw. are used for working up 1,000 kilos. slag. The consumption of acid may be further reduced by previous lixiviation with water, which dissolves free lime. The process of solution is completed in a few minutes. The operation is conducted in stirring-tanks, and on settling the solution is run off from the solid residue, which is then stirred up and washed with a still weaker acid. The solutions are neutralized with milk of lime in large stirring-tanks so far that either all the phosphoric and the silicic acid are thrown down as bicalcic phosphate and calcium silicate, or only so far that only the phosphoric acid and a small part of the silica are thrown down, the bulk of the silica remaining in the clear mother-liquor. To separate the phosphatic mud from the liquid large filter-presses are used, filled by self-acting pumps. The press-cakes contain 65 to 70 per cent. of water. The drying of the cake is effected at Schalke and Stolberg by means of a mechanical apparatus which pulverizes it at the same time. The dry product contains 34 to 38 per cent. phosphoric acid, 6 to 8 silica, 28 to 32 lime, and 1¼ to 2 sulphuric acid, along with small quantities of chlorine, ferric, and manganic oxides, etc. On an average 50 per cent. of the weight of the slag is obtained as a powder of the above composition. These lime precipitates are well adapted for agricultural processes in virtue of their fine state of division and of their high percentage of phosphoric acid. The residue amounts to about 30 per cent. of the gross weight of the slag, and when dried at 100° contains silica, 1·5 to 2 per cent.; phosphoric acid, 0·3 to 4; ferric oxide, 43 to 69; manganic oxide, 10 to 17; lime, 5 to 16; magnesia, 7 to 13. Hence these residues are especially adapted for producing crude irons rich in manganese. Their value is increased by the presence of the alkaline earths, which admits of their admixture with acid ores without any further addition of line.—*Berg und Hüttenmannische Zeitung; Chemical News.*

BENZINE FROM COAL GAS.*

By GEORGE E. DAVIS.

IN my paper read before the members of the Birmingham Section, "On the Distillation of Coal and Extraction of Benzine from the Gas," I endeavored to give a short history of the processes so far as I was able. After the appearance of this paper in our valuable *Journal*, my attention was called to the fact that I had not made any reference to the late Mr. Cusiter's researches. I had already mentioned that in February, 1869, Caro obtained a patent for absorbing benzol by means of heavy oils; but it now appears that Mr. Cusiter made some very interesting experiments in this direction as early as 1868. It is not certain, however, that they were made public until the results were read before the West of Scotland Association of Gas Managers by his brother-in-law, Mr. W. Young, of Paisley, in 1874. Mr. Tervet, whose name is well known to you as the reader of a very interesting paper on "The Production of Ammonia from Coke," has furnished me with this paper, and some extracts from it may be interesting to you, especially as so much has been said lately on the subject of the temperature of carbonization.

It appears that in the winter of 1868 Mr. Cusiter was experimenting with glycerine as a substitute for water in gas-meters. Finding this fluid unsuitable for his purpose, he tried mineral oils; and, to his surprise, when the meter was charged with a mineral oil of 0·840 sp. gr., a 28-candle gas was reduced to 14 candles luminosity. When the same gas was passed through paraffin spirit of 0·768 sp. gr. at a temperature of 50° Fahr., the loss of illuminating power was 5 per cent.; when the temperature was raised to 60° Fahr., the result was *nil;* while when a temperature of 70° Fahr. was employed, the illuminating power of the gas was actually increased some 7 per cent. By passing the same gas through either of the heavy oils, the loss of light was 65 per cent.; while by agitating the oil and gas together "the light giving constituents were almost entirely removed." I mention these facts to show that Mr. Cusiter must have worked very assiduously at this subject; and his conclusions will, no doubt, be accepted as correct by those who have worked in this direction in later years. It is stated that gas made from coal at a low temperature, similar to that used for making paraffin oil, gave a distillate of 34 per cent. of permanent gas and 66 per cent. of liquid hydrocarbons, very similar in composition to light paraffin or petroleum spirit, having a specific gravity of 0·706, and distilling 10 per cent. at 128°

* A paper read before the Manchester Section of the Society of Chemical Industry, Aug. 29, 1884.

Fahr., 50 per cent. at 176° Fahr., and 82 per cent. at 212° Fahr. On the other hand, gas made from the same coal at a high temperature gave a distillate having a specific gravity of 0·872 (very much resembling the most volatile portions of the distillate from ordinary coal tar), and consisting principally of benzines, together with a number of other volatile hydrocarbons. It is most probable that, in actual practice, one series is never obtained in absolute purity. In distilling at high temperatures the aromatic series is slightly contaminated with paraffins, olefines, and other hydrocarbons, which should be separated; while in distilling at low temperatures there are always some of the aromatic series intermingled with the paraffins and olefines.

I recently noticed that a patent had been taken out for the production of benzine by passing the vapor of petroleum through red-hot tubes. I have made a great many experiments on this subject, and am able to say that producers of benzine need not fear any rival in this direction. I have, however, obtained results interesting in another way, and may perhaps read a paper on the subject before this section next session.

Before concluding, I wish to say a few words relative to some remarks printed in a paper read by Mr. Watson Smith before the Liverpool Section. He there says: "Benzol may be recovered from coal gases by means of refrigeration, pressure, and the use of some chemical reagents." * Now, M. Meunier, whose words are quoted, does not give the results of any of his own experiments; and Mr. Watson Smith's remarks are scarcely a correct representation of the result of the German chemists, to whom M. Meunier alludes (evidently Caro's patent of Feb. 19, 1869). It would seem, from the remarks made at Liverpool, that refrigeration was combined with the use of pressure and chemical reagents. It was, therefore, important to ascertain the exact words used by M. Meunier in *Cosmos* (Oct. 30, 1869), as I was not aware that any one had combined the operation of refrigeration with that of absorption for the purpose of extracting benzine from coal gas. On referring to the original, I find M. Meunier is very definite on the subject. He writes: "La benzine employée actuellement dans le commerce a sa source principale dans le goudron obtenu par la distillation de la houille. Cependant, cette substance peut encore etre obtenue par le refroidissement, ou la compression du gaz, ou bien par l'action de différents réactifs, l'acide azotique, l'acide sulfurique, le chlore, le brome, sur le gaz d'eclairage; et au rapport du *Journal de l'Eclairage au Gaz* plusieurs chimistes allemands qui se sont preoccupes des moyens d'extraire la benzine entrainée par le gaz sont arrives à un procede d'une remarquable simplicite. Il resulte de leurs recherches que pour ne point modifier les proprietes chimiques des corps cherchés (la benzine et ses homologues), on doit de preference mettre en jeu des matieres qui peuvent dissoudre ces corps. Dans ce but ils adoptent toutes les huiles de goudron, notamment les huiles qui bouillent a une temperature plus elevee que le degre d'ebullition de la benzine. Le petrole, les schistes, les huiles grasses, une foule de substances semblables, conviennent parfaitement. On met le gaz de houille en contact tres-intime avec les dissolvants que nous venons de citer; la separation se fait ensuite par distillations fractionnees. La separation terminee, on peut reprendre le produit et l'employer de nouveau pour dissoudre la benzine." †

Such was a summary of what was known then; and by the light of recent experience we may be able to criticise the statements. It is very evident that Meunier's idea was that "benzine" might be obtained from lighting gas by cooling. Well, I have tried cooling; and my results have been very unsatisfactory. The ordinary Manchester gas may be cooled down many degrees below zero without depositing anything appreciable.

Compression yields slightly better results, for by compressing an 18-candle gas to 200 lb. on the square inch, I have been able to get, from 1,000 cubic feet of the gas, about 6 oz. of a liquid, consisting mainly of benzine. With regard to the process of dissolving out the "benzine" with heavy oils, I am afraid M. Meunier was but imperfectly acquainted with the process when he speaks about regaining the "benzine" by fractional distillation. Such a process could not possibly yield all the benzine dissolved; and no mention is made of the details which insure a good yield, and so make such a process a commercial success.

I am happy to be able to inform the Section that the process for the extraction of benzines from coal gas, and of utilizing the remaining by products described by me before the Birmingham Section, will soon be actively at work at the Rockingham Gas Works; and I hope also to be a pioneer in the process of carrying on manufacturing industries without the emission of smoke or sulphurous acid. The gas which has been first deprived of sulphureted hydrogen in the ordinary way, and finally of benzol and its homologues, has, to use the words of the *Chemical News* of Nov. 5, 1869, "lost so much of its illuminating power as to be only fit for heating purposes." This will be used for heating the retorts; and by this means I hope to possess an advantage over all other coal consumers, in that the products of combustion will not be in the slightest degree injurious to vegetation. What a change there would be in the aspect of the manufacturing districts of this country if the sulphur were extracted from all the coal used as fuel before actual combustion!

DETERMINATION OF MANGANESE IN IRON.

FROM a contribution by Prof. A. Ledebur to the *Chemiker Zeitung* we translate the following:

Since the introduction of the Bessemer and Martin processes, has the significance of manganese which had hitherto received but little attention in the manufacture of steel continually increased. It is true that the production of pure manganese on a considerable scale will probably never be accomplished, yet the same metallurgical process for the extraction of iron yields an alloy with 80 per cent. manganese. The resistance of this metal to reducing agents, its

* See *Jour. Soc. Chem. Ind.*, vol. ii., p. 500.

† TRANSLATION.—The benzine at present employed in commerce has its principal source in the tar produced in the distillation of coal. This substance may, however, also be obtained from lighting gas by refrigeration or compression, or by the action upon the gas of different reagents, such as nitric acid, sulphuric acid, chlorine, bromine; and, according to the *Journal de l'Eclairage au Gaz*, several German chemists, who are engaged in investigating the means of extracting the benzine contained in coal gas, have discovered a process of remarkable simplicity. It results from their researches that, in order that the chemical properties of the substance sought for (benzine and its homologues) may not be changed, it is preferable to bring into operation certain substances which are capable of dissolving these bodies. To this end they employ all the tar oils, notably those which boil at a higher temperature than the boiling point of benzine. Petroleum, schists, heavy oils, and a number of similar substances, are perfectly suitable. Coal gas is brought into intimate contact with the solvents just named, and separation is subsequently effected by fractional distillation. This operation being completed, the product may be recovered and again employed to dissolve the benzine.—ED. J. G. L.

property to volatilize at the temperature of fusion, the refractory behavior in the fire, and the tendency to fuse at lower temperatures when alloyed with iron and carbon, readily explain that augmentation of the percentage of manganese increases the value of ferro-manganese at a geometrical rate. This fact suffices to induce both manufacturer and purchaser of being well informed as regards the percentage composition of ferro-manganese.

Numerous methods for the determination of manganese have at different times been proposed, but, strangely, not one of these has been generally adopted in laboratories; and the opinions as to the usefulness of one or the other method differ at present. Every analytical chemist practically conversant with the estimation of manganese knows that an accurate determination is the more difficult, the higher the percentage of manganese. The importance of an accurate and ready method for the examination of ferro-manganese and manganese ores to the metallurgist has induced Prof. Ledebur to demonstrate the value of Polhard's, Pattinson's, and Hampe's potassium chlorate method on a basis of comparison of the result obtained by these methods with that by gravimetric determination; its object for examination ferro-manganese was employed, and its percentage composition accurately determined.

1. *Gravimetric Method.*—1 gramme ferro-manganese was dissolved in nitric acid and, on addition of ammonium nitrate, evaporated until no more acid vapors were given off; the residue redissolved in muriatic acid and diluted with water to ⅜ liter. An adequate quantity of ammonium chloride was introduced, and the solution neutralized by ammonium carbonate until it became turbid. On adding 1 c. c. acetic acid to the solution and heating to boiling temperature iron sesquioxide was precipitated, which was lixiviated with hot water containing ammonium chloride, again dissolved in muriatic acid, and the treatment repeated. The last portions of iron were then removed from the combined filtrates; they were filtered, exhausted with water, redissolved, and precipitated. The ammoniacal filtrates, containing manganese, copper, nickel, and cobalt, were acidified with acetic acid, and a current of hydrogen sulphide passed through the solutions. Manganese was finally deposited from the boiling filtrate by means of ammonia and ammonium sulphide, converted according to the method of H. Rose into manganese sulphide, and weighed. The percentage of manganese thus determined was 46·22 per cent., and two days were required for the determination.

2. *Polhard's Method.*—1 gramme ferro-manganese was digested with nitric acid, evaporated to complete dryness, redissolved in muriatic acid and a small measure of sulphuric acid added, then heated on a sand bath, for the purpose of expelling muriatic acid, until fumes of sulphuric acid were evolved. The remainder dissolved in water, transferred to a liter flask, neutralized by sodium carbonate and zinc oxide, previously rubbed with water to a cream, introduced. The flask was filled up to the mark, well shaken, the liquid filtered through a dry filter, and aliquot parts, *e. g.*, 200 c. c., equivalent to 0·2 gramme, used for titration. Each division was acidulated with 2 drops of nitric acid, boiled, and standard solution of potassium permanganate run in from a burette until the color of the solution had changed to red. The mean result of two examinations was 46·27 per cent. of manganese, and ten hours required for conducting the tests. This method has the advantage that one solution can be used in several examinations, which is of value in accurate analytical work; but the end reaction is obscured by the suspension of manganese dioxide in the solution, which subsides slowly.

3. *Potassium chlorate method of Hampe.*—0·3 gramme ferro-manganese was digested in a beaker of 400 c. c. capacity with 25 c. c. nitric acid of 1·18 s. g. and heated with cover on for two hours; 5 grammes potassium chlorate were then successively added to the gently boiling solution, which was then diluted with hot water. The precipitate was thrown on asbestos filter, which had been washed with muriatic acid, and then ignited, and exhausted with hot water. The last washings were tested for chlorine with potassium iodide and starch. Precipitate and asbestos filter were returned to the beaker, and deoxidized by an acid solution of ferro-sulphate of known standard, which had been obtained by dissolving 50 grammes well crystallized ferro-sulphate in a mixture of sulphuric acid and water, *i. e.*, 250 parts acid to 750 parts water; after complete solution of the manganese the liquid was further diluted with water, and manganese determined by titration with potassium permanganate. The deoxidizing effect of an equal portion of the acid ferro-sulphate solution was then volumetrically determined by use of the standard potassium permanganate liquid, and the difference of both results was used as basis of calculation. As a mean of three determinations a number was obtained equal to 46·35 per cent. manganese, and the time devoted to the examination was ten hours. The digestion of the precipitate with a small amount of acid at a raised temperature for two hours is an objectionable feature of this method, and when the water-bath is replaced by a sand-bath, or the liquid heated over an open flame, the liability of spoiling the test is seriously incurred.

4. *Pattinson's method.*—For the determination by this method, 0·3 gramme of ferro-manganese was placed in a beaker of 400 c. c. capacity and treated with aqua regia, 3 c. c. nitric acid, and 6 c. c. muriatic acid, at a low temperature. The solution was cautiously concentrated, to expel the excess of acids, to a sirupy consistence, dissolved in 5 or 6 c. c. cold water, neutralized by calcium carbonate till the color of the solution is changed to brown and a portion of the iron is precipitated. Fifty c. c. of a solution of bleaching powder, obtained by dissolving 15 grammes bleaching powder in 1 liter cold water and filtering the supernatant liquid, the temperature of which had been raised on addition of hot water to 80° C., were then added, the solution continually agitated, and small portions of calcium carbonate added from time to time till a small quantity had settled to the bottom. A portion of the supernatant liquid was then filtered and tested with ammonium sulphide for manganese. By following the mode of operation here laid down, an incomplete precipitation of manganese is not likely to occur. When the solution has a red tint through the presence of permanganic acid it is reduced by boiling, with an addition of alcohol, and converted into manganese dioxide. The precipitate was thrown on a filter of medium size, exhausted, and both precipitate and filter replaced in the beaker, dissolved in 50 c. c. of the acid solution of ferro-sulphate, and further treated as in the precedent examination. The mean of two examinations represented a percentage of 46·28 per cent. manganese, and consumed 5½ hours' time. The results obtained by this method compare well with those by Polhard's; it can be considered a convenient and fairly accurate method, and is therefore well adapted for the laboratories of iron and steel works. It is possible to perform seven manganese tests during one day where facilities

for quick filtering of the solutions are given. Copper, cobalt, and nickel, metals which are generally associated with iron in ferro-manganese and pig iron. influence the result by their oxidizing action on ferro-sulphate, and the number indicated by this method is too high by a fraction of one per cent. When copper is at the commencement of the reaction deposited by ferro-sulphate, it is redissolved by the excess of acid without acting on iron protoxide: but when the precipitate consists of cupric acid the protoxide is then converted into iron sesquioxide, according to the equation: $Cu_2O_2 + 2FeO = Fe_2O_3 + 2CuO$, i. e., 1 gramme of copper oxidizes $0·9$ gramme iron, through which is caused an augmentation of the percentage of manganese by $0·44$ per cent. The quantity of copper in ferro-manganese and pig iron ranges from $0·1$ to $0·2$ per cent., and never exceeds $0·4$ per cent.; the latter of which two quantities increases the percentage of manganese by $0·17$ per cent. Of still less influence are nickel and cobalt, which conjointly seldom exceed $0·5$ per cent. in ferro-manganese.

When the numbers obtained by this method are found to be too high, the cause must be assigned to careless manipulation, specially to the use of too large a filter and to imperfect edulcoration of the precipitate. The filter then retains particles of bleaching powder, which react with ferro-sulphate and increase the percentage of manganese; for this reason all traces of bleaching powder, must be dissolved out with water. A measure of from 1 to 2 c. c. of the washings is collected in a test tube, acidulated with one drop sulphuric acid, and examined by a solution of starch and potassium iodide. The objection that the end reaction by using potassium permanganate in titrating ferric sulphate is not well defined, cannot be maintained, for the solution is discolored

expending or misappropriating in ten years upward of four millions of rubles, were banished and their estates confiscated. The Emperor Nicholas adopted new plans, and chose the present site, which has cost, with embankment, terrace, etc., upward of £180,000. and whence, at the onset, a nunnery had to be removed, and 70,000 cubic feet of earth to be displaced, before, on the 27th July, 1838, the laying of the foundations was commenced. The building continued slowly to rise for 20 years, and in 1858 the scaffolding was removed, this latter item alone having cost 277,000 rubles, or upward of £40,000 (reckoning the ruble, that is, at 3s., as throughout this letter). A quarter of a century more has been expended on fittings and decoration. The style is ancient Russian, or rather Græco-Byzantine, the most striking feature of which, to a Western eye, on the exterior is the five copper cupolas, for the gilding of which were required 900 lb. of gold, their total cost being upward of £170,000. The domes are surmounted by crosses, the center one, nearly 30 ft. high, standing 340 ft. from the ground. The building covers an area of 73,000 square feet. The bells, as usual in Russia, are of ponderous weight. The largest, or "holyday" bell, weighs 26 tons, or half as much again as "Great Paul." Even the second, or "Sunday," bell is within a ton's weight of our bantling; while the smallest of the "every-day" bells descends to about 30 lb. The cost of the peal was upward of £13,000.

The foundations of the church are of Finnish granite, and the whole edifice is faced with marble, the doors being of bronze, ornamented with Biblical subjects and lined with oak. The principal entrance measures 30 ft. high by 18 ft. broad, and the two doors weigh 13 tons, the total cost of all the doors being £62,000. Thus, it will be allowed that many

000, with a second row of 600, costing an additional £12,000. There are four lusters weighing 4 tons each, and the total number of candles to be lighted throughout the building is upward of 3,000. At the top of the cupola is a painting by Professor Markoff that will freely shock the principles of Westerns, who object to the use of pictures in worship. It represents in colossal proportions the first person of the Blessed Trinity as an old man with the infant Jesus. The height of the figure is 49 ft., the length of the face 7 ft., and the height of the infant 21 ft. Also, below the cupola are a number of figures of Apostles and Fathers each 21 ft. high. Great expense has of course been lavished on the eastern end of the church. The cost of materials and workmanship for the altar-space, apart from the icons or sacred pictures, amounted to £36,000.

In this part of the church are some of its most remarkable paintings, most, if not all, by Russian artists. They are too numerous to particularize. I remarked, however, a striking picture of Sergius blessing Demetrius of the Don. I see from my notes that "The Last Supper," by Semigratzky, and eleven pictures by Verestchagin attracted my attention. The structure of the altar screen is a departure from the traditional Russian type, for instead of a tall, ugly blank partition, half or two-thirds of the height of the church, hiding the eastern end, the screen of St. Saviour's is low and elegant, and throws open, except for a few feet above the floor, the whole of the sanctuary. But a more marked and, as some would think, unorthodox departure from the customs of the Russian Church is the construction of the altars. I am under the impression, gathered, I think, from the work of the learned Dr. Neale on the Eastern Church, that the "holy table" in the Russian Church should be always

SUGGESTIONS IN ARCHITECTURE.—A PAIR OF SEMI-DETACHED COTTAGES.

Frank M. Harvey Del.

on heating or on addition of a few drops of sulphuric acid. For various reasons should the liquid be diluted and measure 200 c. c., as such a solution will yield satisfactory results.

COTTAGES NEAR FLIXTON.

THESE cottages are so designed as to appear as one house only. The site is an open one, commanding good views. The walls are to be of local red brick, the strings and sills of moulded pressed brick, the upper portion being tile hung, and the roof covered with small green slates. The estimated cost is £720 the pair. The architect is Mr. Frank M. Harvey.—*Build. and Eng. Times.*

NEW CATHEDRAL OF MOSCOW.

THE new cathedral at Moscow, writes a correspondent of the *Times*, is one of the most remarkable churches in Europe. Not many cathedrals can boast of having been built in one lifetime, but there are Russians still living who saw the French army depart from Moscow, to commemorate which event the church of St. Saviour has been erected. In less than three months after the retreat of the foe a decree went forth from Alexander I. that a memorial temple should be built, and five years later the foundations were laid. But not on the present site. The Emperor accepted plans which, had they been carried out, would have given to Russia the highest building in the world, namely, 770 ft., the site being on the Sparrow hill, between the routes of the entrance and departure of Napoleon, but the undertaking for a while collapsed, and the architect and building committee, after

of the features of St. Saviour's are produced on a magnificent scale, though one familiar with the spire of St. Stephen's Vienna, or that of Salisbury, the west front of York Minster, or that of Amiens, might hesitate to pronounce the effect of the exterior of St. Saviour's beautiful. As to the interior, there can be, I think, little difference of opinion. I have seen most of the celebrated cathedrals in Europe (with the exception of those of Spain), but in its way I know of nothing so exquisite as the interior of St. Saviour's at Moscow. The building is erected in the form of a Greek cross, three of the broad ends of which form corridors, lower and upper, surrounding three sides of, and open to, the central square or temple proper, while the fourth end is occupied by the altar and its appurtenances. The upper corridor reminded me of the galleries in Santa Sophia at Constantinople. The walls are adorned with frescoes illustrating principal events in the history of the Russian Church. The walls of the lower corridor or "procession gallery" are adorned with paintings commemorative of the battles of 1812.

But it is when one stands in the temple proper and looks above and around that the gorgeousness of the building is so striking. The floor of this part is 220 ft. square, the length of the cross either way 270 ft., and the height from the ground to the cupola measures 230 ft. The floor is of marble, and the walls are lined with exquisite varieties of the same material. It was intended at first to use only Russian marble, but some amount of Italian was subsequently found to be indispensable. The total cost of all the marble in the building exceeded £300,000. Lifting one's eyes the galleries are seen to contain 36 windows, and the cupola 16, all of which are double, with frames of bronze. Round the cupola is one row of 640 candelabra, placed there at a cost of £27,-

of wood, whereas in St. Saviour's I saw two at least constructed of blocks of polished marble, the semblance of a table being given to each by a movable inch board of cypress wood laid on the top. Much of the ornamentation of the sanctuary and its furniture is exceedingly beautiful, notably some enameled candelabra by Klebnikof, but perhaps I have sufficiently described this princely cathedral, erected at a cost of two and a quarter millions of pounds sterling, said to be capable of accommodating 10,000 worshipers, and which from its first conception has been built, as I have said, in a single lifetime.

FUSEL OIL IN CANDIES.

DR. E. H. BARTLEY, chemist to the Brooklyn Board of Health, has made a report to that body in regard to the "rock-and-rye drops," which, although flavored with fusel-oil, are constantly sold at the "candy shops" in large quantities to school children, and in it he says: "In some of these candies the oil is not thoroughly mixed or diffused, and occasionally a good sized cavity is filled with fusel oil. Estimating that a child may buy and eat a half pound of this candy, containing $5·7$ grains of the oil, it will be seen that it will take the maximum dose for an adult, and will probably experience distinct symptoms, such as dizziness, headache, or even slight intoxication. A fatal dose of fusel oil is stated by the best authorities to be from $1·4$ to $1·6$ grammes, or the quantity found in two pounds of this candy." "Jargonel pear drops" and other "sweets" of the kind are, we believe, liable to a like objection.—*Brit. Med. Jour.*

THE TONKIN GIBBON.

The Museum of Natural History, of Paris, has the good fortune to possess at present an anthropoid which has been hitherto unknown, and which was brought from Tonkin by Dr. Harmand. We are happy to be able to make the animal known to our readers. Mr. Alph. Milne Edwards has named it the large-nozed Gibbon, *Hylobates nasutus.*

There could be nothing more graceful and elegant, and at the same time stranger, than this little animal with his immense arms, which are, as in all Gibbons, longer than his legs. He is wonderfully dexterous and supple, and is one

Fig. 6.—THE TONKIN GIBBON.

of the most skillful of gymnasts. We could not repress our astonishment upon seeing this dear cousin cut up his capers with so surprising nimbleness, and, upon comparing him with our acrobats, we had to admit that *their* vaulting was heavy and awkward. We were humiliated upon thinking of our inferiority.

Suddenly leaving his retreat he will dart forward, seize the bar that traverses his cage with one hand, fix himself by his two feet and the other hand to a cord hanging from overhead, and, head downward, gaze at you with a bantering air (Fig. 1). An instant afterward, jumping to the ground, near the vessel containing his food, he will crouch down in a peculiar posture, and, with his legs pressed to his side after the manner of a frog, his arms extended, and his hands against the wall, he will closely inspect the food that has

been given him (Fig. 2). Having made his selection, he will, for example, seize a carrot, and quick as a flash ascend to the bar in order to assume a position which is not less original; with his right arm hanging down, his left extended and his hand grasping the bar, his right leg bent and his foot resting upon the bar, he will hold the carrot with his right foot and gaze upon it with admiration (Fig. 3). Sometimes he will place himself at the point of intersection of the two bars that run horizontally through his cage, and carelessly stretch himself out in the position of one crucified (Fig. 4). If his imagination invites him to activity, he will suspend himself in one of the boldest of positions (Fig. 6),

and then jump nimbly to the ground near the vessel containing water for him to drink. Here, with his legs bent under his body, his left hand resting upon the ground, and his right resting against the wall, he will gaze fixedly at the liquid (Fig. 5).

This Gibbon is exceedingly sociable and affectionate, and became very much attached to his master, Dr. Harmand. When our artist, Mr. Clement, was sketching him, he came and seated himself familiarly upon the latter's knees, and took his pencils away from him.

As regards his person, the animal is entirely black, and his face, ears, and the inside of his hands are hairless. When he fixes his great black eyes upon us, we are surprised to see a fine and delicate little nose emerge from the middle of his face. This is an important character, for, with rare ex-

ceptions, the possession of a projecting and well pronounced nose is a privilege belonging to man. Although, as Darwin has observed, there is a beginning of an aquiline curvature in the nose of the Hoolock Gibbon, the other species usually have a flat nose. The presence of a nasal appendage whose form is sharply defined, therefore, constitutes an important character, and justifies the name *nasutus* given to the animal under consideration.

Unfortunately, Dr. Harmand was unable to obtain much information about this Gibbon. He found him on the coast of Tonkin, in the vicinity of Along Bay. May it not be the black Gibbon, which Swinhoe mentions as existing in the region to the west of Canton, and perhaps even in the island of Hainan? Let us note in passing that authors are by no means agreed as to the number of species of *Hylobates,* and this contributes to confuse the synonymy. While Murray admits but four species, Anderson makes eight.

For want of observations upon the large-nozed Gibbon, we give a few details regarding the habits of these animals, according to studies made in this direction in recent years. Being exclusively inhabitants of trees, it is easy to see that Gibbons can only feed upon leaves or such birds and insects as select the tops of trees for their dwelling-place. It has been found, in fact, that *Hylobates Hoolock* is fond of the leaves of several different trees ; that he eats with avidity, like certain monkeys, small shoots and the leaves of beets and of an aquatic bind weed ; and that he has a manifest predilection for the flowers of the Indian shot (*Canna Indica*). The Hoolock, like his congener, the Lar Gibbon, has a marked preference for spiders and their webs, which he delights in entangling with his long and tapering fingers, and he receives with a cry of satisfaction such orthoptera as may be offered to him. He is a passionate lover of small birds, and is probably a great destroyer of these animals. He is also fond of eggs, and is certainly as great a nest hunter as the Nycticebus. Gibbons live in large bands, which have been estimated by Anderson to consist of a hundred or a hundred and fifty individuals. They possess surprising agility, and will jump more than thirty feet from branch to branch, shaking the trees violently, catching hold of the branches with extraordinary precision, disappearing in the twinkling of an eye, and flying as if they had wings. They are the most cunning animals imaginable, and it is almost impossible to get a chance to kill one. Even when wounded they manage to get away, being aided by their comrades, and go to die in the fork of an inaccessible tree.

The cry of the Gibbon is so peculiarly modulated that it can never be forgotten by any one who has ever heard it. Nothing can give an idea of the melancholy and inexpressible sadness of these modulations, which are prolonged into heart-rending sobs that start from every part of the forest as soon as day begins to break. The impression is so strong and poignant that one has need to appeal to his reason in order not to be seized with true pity for these animals, and not to give way to the illusion that these songs of death and mourning have any significance to them.—*Science et Nature.*

FIG. 3   FIG. 4

FIG. 2   FIG. 1   FIG. 5

FIGS. 1–5.—THE TONKIN GIBBON IN VARIOUS POSITIONS.

ELECTRIC FISHES.

CERTAIN animals possess electric properties such that they have been compared to the piles or machines which we use in the laboratory to produce electricity. It is in the class of fishes that we find beings endowed with this physiological peculiarity. They are few in number, as regards species, and are known as electric fishes.

As was remarked by Geoffrey Saint-Hilaire, analogy would lead to the belief that beings which enjoy so extraordinary faculties owe them to an organization nearly alike in all cases, and that they are consequently closely related to one another, or rather that they form one and the same family. Thus, we find that insects which have vesicatory properties form, in the large group of Coleoptera, a well characterized tribe in which all the genera and species are epispastic in varying degree. Such, however, is not the case with electric fishes.

Saint-Hilaire, who was greatly struck by the distribution of the electric species among genera that were sometimes widely separated by all their other characters, tried through this fact to explain that the organs producing electricity "were not essentially connected with organs of the first rank, and that they belonged at the very most to common integuments which vary in each species, without bringing any notable modification to the balance of the organism."

We shall see in the sequel that the idea expressed by the learned naturalist-philosopher is correct, and that in fact the electric organs may seemingly be considered as developing at the expense, not of the integuments, but of the muscles—organs which may be partially modified without affecting the general organization of animals.

However this may be, electric fishes are, as we have said, few in number, and belong to very different genera. In some, the structure of the electric organ is well known, and its effects have been carefully studied; these are the torpedoes, the rays, the gymnotus and the electric silurus. In others, the electric organ has been described, but its properties have only been suspected, for want of opportunity to experiment upon them; such are the mormyrus and the gymnarchus of the Nile.

We shall mention, finally, and only *en passant,* three other species in regard to which we have but meager information, to wit: (1) The electric trichiurus, a fish of the Scomberoid family inhabiting the seas of India, but one which, *fide* Lacepede, was established upon a confusion existing between the text of Neuhof, who described it, and the figure that is referred to it; and (2) the electric tetrodon, a species of the group of Plectognathi, which was met with at the Comore Islands, and was mentioned by Lt. Paterson in a letter to Sir Joseph Banks in 1786. This English officer relates that, having placed this fish in a cloth bag, he experienced so violent shocks that he was obliged to let go of it. The organ that produced these effects, however, was neither looked for nor described. (3) The electric rhinobatus, regarding which we have no data.

We shall therefore pass over these three last species, and occupy ourselves only with the first six.

The torpedoes and rays are fishes of the group Plagiostomi, which dwell by preference in the depths of the ocean. The torpedoes usually inhabit warm or temperate regions. There are several species in the seas of India and upon the coasts of America, and in Europe they especially frequent the Mediterranean, but they are not rare on the coasts of Brittany. The other electric fishes are found in fresh water. Thus the *gymnotus,* or electric eel (Fig. 2), which belongs to the group of apodal malacopterygians, and is related to the *Muræna* and the eels, lives in the rivers and marshes of South America. The *Malapterurus,* or electric *silurus* (Fig. 1), is abundant in the waters of the Nile, which are inhabited likewise by the *gymnarchus.* The *mormyri,* finally, live in the rivers of tropical Africa. These three
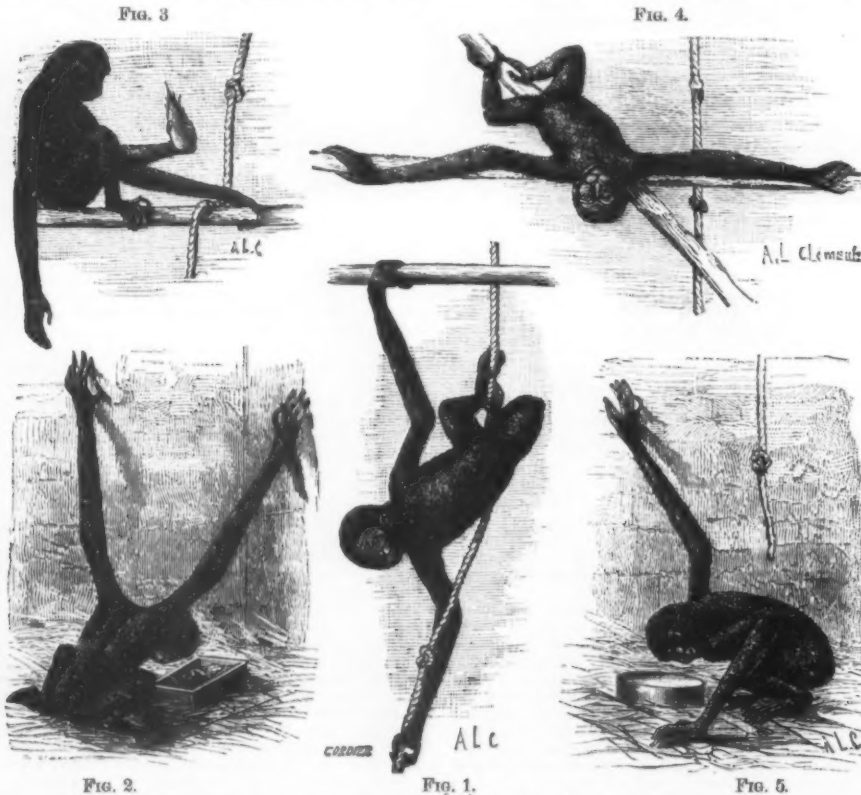
latter species belong to the group of abdominal malacopterygians.

From what precedes, we may conclude, then, that electric fishes are distributed through different groups of the class —some belonging to cartilaginous fishes and others to osseous ones   The great area of their geographical distribution is none the less interesting.

As for the use that is made of the electric organ by fishes that are provided with it, this is easily divined. It is employed as a weapon of offense or defense. To prove this we cannot do better than make known some of the observations that have been made upon the torpedo by Armand Moreau, who has carefully studied this animal's habits. As well known, the torpedo is a cartilaginous fish which has a depressed body, and which much resembles the rays, and lives in the sea, where, lying at the bottom, it remains more or less completely buried in sand. Hidden there, it waits until its prey comes within range. Let a fish pass, and the discharge, which is literally as quick as lightning, strikes the victim, paralyzes it for a few moments, and allows the torpedo to swallow it before it has regained its power of moving. The size of the fishes attacked by this animal is sometimes considerable.

The same physiologist one day saw a torpedo that was lying in the bottom of a boat take satisfaction out of a turbot of the same size as itself. Scarcely had the latter (which had just been caught) slid to the bottom of the boat when it was seen to take an immense leap, and then remain immovable for a minute, with its body bent double in a violent contraction. Another day a distorted torpedo having been opened, there was found in its stomach a sole which was

FIG. 1.—ELECTRIC SILURUS.

bent double and which in length was almost equal to its host. The electric discharges, then, are dependent upon the animal's will, and permit of the latter's using them to seize upon the prey that it covets. But it can also use them for defense, and, as regards this, we cannot pass over in silence the narrative that Humboldt gives concerning the capture of Gymnosi by means of horses and mules, which the Indians drive in large numbers into the marshes where these fishes are found.

"The extraordinary noise caused by the stamping of the horses starts the gymnoti from the mud, and excites them to combat. These yellowish and livid eels, like large water snakes, swim upon the surface and crowd under the bellies of the horses and mules. A contest between animals of so different an organization affords a most picturesque sight. The Indians, provided with harpoons and long thin reeds, closely surround the marsh, and, by their wild cries and the length of their reeds, prevent the horses from escaping to the banks. The eels, bewildered by the noise, defend themselves through the repeated discharge of their batteries and, for a long time, appear to have gained the victory. Several of the horses succumb to the violence of the unseen blows that they receive on every side in the organs most essential to life. Bewildered by the force and frequency of the shocks, they disappear under the water. The eel, being five feet in length, and pressing against the horses' bellies, makes a discharge throughout the whole length of its electric organ. It attacks at once the heart, the viscera and cœliac plexus of the abdominal nerves. . . . We doubt not that the fishing would end in the successive death of all the animals employed in it. But, gradually, the fury of this unequal combat diminishes, and the tired gymnoti scatter. They need a long rest and an abundance of food in order to make up for what they have lost in galvanic force. The mules and horses appear less frightened, they no longer erect their manes, and their eyes show less terror. The gymnoti timidly approach the shores of the marsh, where they are captured by means of harpoons attached to long cords. When the cords are very dry, the Indians, upon lifting the fish in the air, experience no shock."

We shall have to return to this account of Humbolt's, for it contains interesting remarks upon the mode in which the electric organ of the gymnotus operates.

The preceding facts, which we might multiply *ad infinitum*, show how powerful is the action that electric fishes are capable of exerting. For a long time nothing at all was
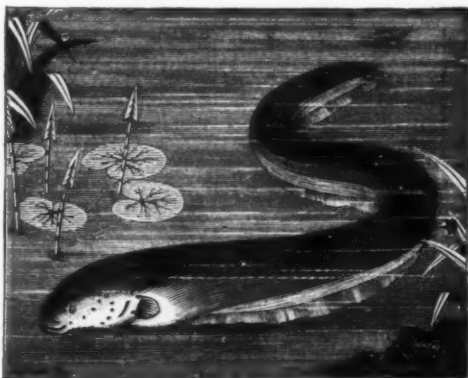

FIG. 2.—GYMNOTUS.

known about the nature of this action, and the most diverse theories were advanced to explain the effects that are produced by the singular animals under consideration. The numbness that they produce when they are touched caused the ancients to give them very appropriate names. The Greeks called them *narke*, signifying "stupor;" from this also the Latin name, *torpedo*, "torpor," and the modern names, magician-fish, cramp-fish, etc. But these names, although they recall the effect produced, do not indicate that the cause of it has been suspected. The Arabs, however, as Saint-Hilaire remarks, perhaps had an inkling of the relation

between celestial electricity and the phenomena produced by the torpedo and electric silurus.

"The Arabs," says this author, "at the epoch, doubtless, in which they were so successfully cultivating the sciences, were on the road to the theory of electricity ; at least it is very likely that they referred the effects of the torpedo and those much more terrible ones of celestial electricity to the same cause. . . . Every animal bears in this country, as in the books of naturalists, two names, that of the genus and that of the species. About the only exception to this is the case of the torpedo and silurus. Everything
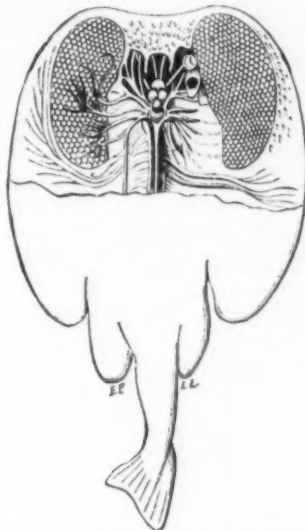

FIG. 3.—TORPEDO WITH ELECTRIC ORGANS EXPOSED.

touching the shape of these fishes has been neglected, and attention has only been paid to their wonderful faculty of striking all the small species of the ocean and river numb, so, although very different, they are called by the same name, and, what is very remarkable, by that of *raad* or *raasch*, which means ' lightning.' "

Aristotle thought that the torpedo caused numbness in the fish that it wished to capture, through a venom that was proper to it. Athenæus, Theophrastus, Pliny, Plutarch,
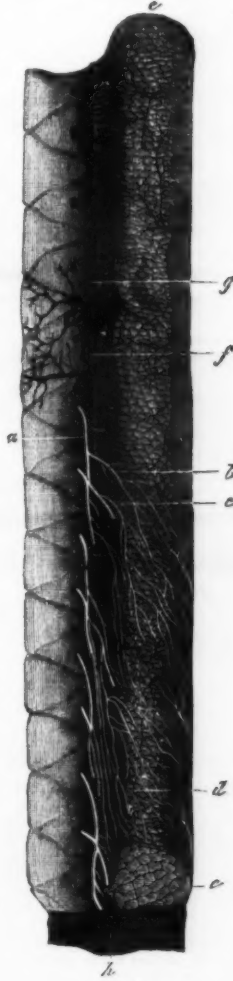

FIG. 4.—POSITION OF THE ELECTRIC APPARATUS OF THE RAY.

and Dioscorides likewise observed, without any better explanation of them, these curious benumbing phenomena, and Galen attributed them to a frigorific principle. Later on, in the 17th century, Redi (1671) and Lorenzini (1678) studied the organs peculiar to the torpedo, and found that they were the source of the effects that they observed ; but they put forth a very singular theory. Considering, in effect, this organ to be formed of muscles—*musculi falenti* (which they called so because the organ of the torpedo is bent like a sickle)—they supposed that these in contracting threw to a distance delicate corpuscles which produced

numbness in the animals or limbs that they reached. The existence of these corpuscles was not generally admitted, and purely mechanical theories were soon substituted therefor. Thus Borelli asserted that the torpedo, seized of itself with violent tremblings, communicated these movements to the animal that touched it, and thus caused a painful numbness in it.

Reaumur, who was somewhat incredulous, and who thought the narratives that he had read were exaggerated, resolved to make some experiments upon the torpedo, and upon doing so, found to his great astonishment that upon
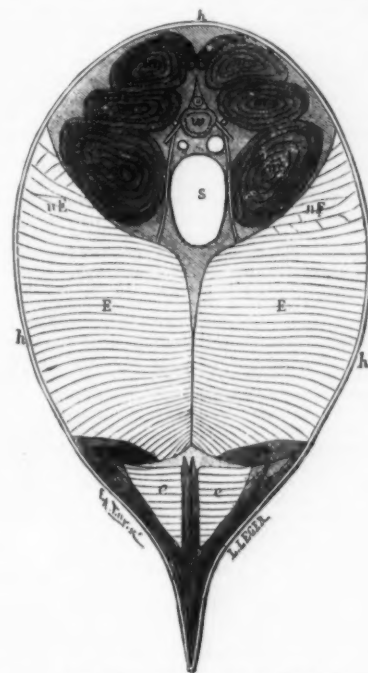

FIG. 5.—ARRANGEMENT OF THE ELECTRIC ORGANS OF THE GYMNOTUS.

placing his hand in contact with the animal his entire arm, up to the shoulder, was struck with numbness accompanied with a sharp pain that he compared to the sensation that is felt when one strikes his elbow against a hard body. He then tried to explain this phenomenon as due to a violent blow that the torpedo gives the hand that touches it. The percussion would be composed of a considerable number of small blows following one another rapidly, and each produced by a contraction followed by a sudden relaxation of the cylinders that compose the organ peculiar to the torpedo, and the structure of which had been made known by Redi and Lorenzini. These bodies, says he, "produce in the nerves an undulatory motion which does not reconcile itself with the one that we have to give them in order to move the arm, and hence comes the powerlessness to use it and the painful feeling that we experience."

We must not be astonished to see Reaumur, the sagacious observer, depart thus from the truth and not suspect the presence of electricity, for he did not, in fact, know the properties that characterized the latter. Nothing can better demonstrate the ignorance that then existed in regard to this agent than the following extract from his memoir : "If we are to believe what has been told us about torpedoes in the history of Abyssinia, if they are capable of causing the death of live fish, they seem to bring to life dead ones. Dead fish, it is said, become agitated if they are placed in the same vessel with them. But is not such a story too much to believe ?" Thus it was that Reaumur treated an observation which is the very demonstration of the electric power of the torpedo. Toward the middle of the 18th century, the progress of the physical sciences becoming more pronounced, a true explanation of the phenomena was arrived at.

An English physicist, Walsh (1772), was the first to demonstrate experimentally that there was a production of electricity when the proper organs of the torpedo entered into play. Before him, however, this opinion had been put forth by Adanson (1757), in order to explain the shocks produced by the electric silurus of Senegal. At present we can have no doubt as to the nature of the discharges that astonished our predecessors, and the electric fishes in every
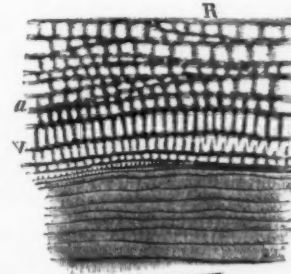

FIG. 6.—SECTION OF A PORTION OF THE ELECTRIC ORGAN OF THE GYMNOTUS.

respect merit the name that has been given them. We shall in the first place demonstrate that these animals owe to electricity the properties that they enjoy, and afterward endeavor to find out where and how this electricity is produced.

ELECTRIC APPARATUS.—DESCRIPTIVE ANATOMY AND TOPOGRAPHY.

In the electric organs of all fishes there are two parts to be considered, to wit : one, of the nerves, and the other a peculiar organ in which the latter are distributed. The

nerves are more or less developed and specialized. As for the organs, they always consist essentially of disks or plates (electric plates), sometimes very numerous, which, in their mode of arrangement, grouping, etc., offer variations in the different species, while always preserving the same characters in individuals of the same species. The most recent investigations tend to demonstrate that these organs have their origin in modified muscles, so we must not be astonished to see them occupy the vicinity of more or less powerful muscles that sometimes completely envelop them.

Electric Apparatus of the Torpedo.—As we stated above, the torpedo is a fish quite frequent in our seas, and so it has been the subject of many researches. Hunter (1773) was the first who gave a satisfactory description of the electric apparatus of this fish. Since then, the study of it has been taken up by different anatomists, and more particularly by Geoffrey Saint-Hilaire and Savi. It was not till later that, by the aid of the microscope and improved methods of investigation, we came to have a profounder knowledge of the organs, and, at the same time, a correcter appreciation of the mode of production of the electricity.

The nervous apparatus of the torpedo consists of four large trunks that have their origin in the elongated spinal marrow. Their size is such that it appeared to Hunter "as extraordinary as the phenomena that they give rise to." Three of these branches correspond to the anterior pneumogastric nerves (Fig. 3), while the fourth is a trigeminous one. They are distributed for a short distance through the different regions of the electric organ, where they ramify. At the level of the apparent origin of these nerves, behind the cerebellum, there is a pair of quite large nervous swellings which cover the rhomboidal sinus and are known as "electric lobes"—a name that they owe to the important role which they appear to perform in the operation of the electric organ. This latter constitutes on each side of the fore part of the torpedo's body a crescent-shaped, externally convex mass which is lodged in the interval comprised between the head and the cartilage of the pectoral fins. Behind, it is prolonged as far as to the middle of the abdominal region. If, at the level where it is seated, the skin be removed, there will be seen both upon the dorsal and ventral face of the animal a number of small polygonal faces, which are slightly convex and pressed against one another, and which recall the arrangement of a honey comb. These surfaces are the bases of ordinarily six-sided prisms that are placed side by side and run vertically throughout the entire thickness of the body. The number of these prisms is very variable, and, according to the size of the animal, may be computed at from 500 to 1,500. They are isolated from each other by membranous partitions that are continuations of the tunica conjunctiva that invests the entire organ. Finally, horizontal partitions which emanate from the preceding, and are of conjunctive nature, divide the prisms transversely into superposed plates or disks, which we shall study further along, and in the lower surface of which disappear the last nervous ramifications.

In short, the electric organ of the torpedo is reniform. It lies in the anterior region of the body, and the nerves penetrate it through its internal concave surface. Enveloped in a continuous sheath, it occupies the entire thickness of the body, and is found immediately beneath the skin.

In other electric fishes the structure of whose organ is sufficiently known to permit us to speak of it here, it is likewise formed of superposed disks, but the columns that they form run, not from the dorsal to the ventral surface, but from the anterior to the posterior extremity of the body. These columns, in a word, lie parallel with the axis of the body.

Rays.—Thus in rays, for example, which are closely related to torpedoes, the electric organ consists (Fig. 4) of a fusiform body composed of cells each containing a disk in which ends a nervous thread. These cells are superposed in series parallel with the axis of the body, and the disks run in such a way that one of the surfaces is anterior and the other posterior with respect to the animal's body. This apparatus, which is in great part enveloped by the sacro-lumbar muscle, lies in the tail, and not in the anterior region of the body as in the torpedo. Mr. Robin, who was the first to make a complete study of the electric apparatus of these animals, has observed it in a large number of species, among which we may cite *Raia Batis, R. rubus, R. clavata* and *R. undulata*.

The Gymnotus.—In the gymnotus, a species related to the eels, the electric organ comparable with that of the rays is composed of disks placed as before, and suspended in small cells formed of the intercrossing of thick partitions parallel with the axis of the body, and of thinner transverse partitions. The collection of cells comprised between two parallel, longitudinal partitions forms a column analogous to that of the torpedoes and rays. The organ thus formed is a yellowish fusiform mass (Fig. 5, E) of gelatinous consistency, which extends parallel with the axis of the body from the caudal fin up to the extremity of the tail, that is to say, it occupies almost the entire length of the animal.

One of these organs exists on each side of the body. They are placed beneath the swimming bladder (Fig. 5, *s*), which, in this species, is prolonged very far behind, and their upper edge is covered by the lateral muscles (see Fig. 5, *m*), of which, according to Sachs, they are a genetic appendage. Their lateral surfaces are placed immediately beneath the skin (A), and, finally, their lower surface is limited by a tissue as to whose nature there has long been a doubt, and in which Du Bois Reymond has found muscular fibers. Their size is considerable, and they take up most of the space in the middle of the lower region of the tail.

Such are what Hunter called the large electric organs of the gymnotus. Besides this there are small organs. These (*e*) lie beneath the preceding, from which they are separated by the lower muscular plane (*m*), of which we have spoken above (the *Zwischenmuskelschicht* of Du Bois Reymond). They extend in the same direction as the large organs, and begin and end nearly at the same place as they. They affect the form of triangular pyramids, and their lateral faces are covered by the muscles of the fin, of which they seem to be a transformation. In fact, according to the recent researches of Sachs, published by Dr. Reymond, these muscles are wanting or incompletely developed where the small apparatus exists.

This is not all; there is in the gymnotus, *fide* Sachs, a third electric apparatus (*s*, E) situated over the large organ at its posterior part. It begins in a point in front, and then, increasing in size behind, it trenches upon the large organ and ends by replacing it entirely. This special apparatus, which is distinguished by its transparency and reddish-yellow color, is formed in the same way as the other electric organs of the animal, but the cells which contain the disks are from ten to twenty times more spacious (Fig. 6, R, V, H) than the ordinary ones. Dr. Reymond does not think, however, that this part of the large organ is to be distinguished as a pecu-

liar organ, and proposes to give it the name of "Sachs' fasciated columns." These columns of giant cells appear, moreover, to have been observed by Pacini, who figured them. He expresses himself as follows: "In one angle of a fragment of the electric organ I have found a small number of series of diaphragms so irregular that I have had to distinguish them by the name of *abnormal diaphragms*. These diaphragms were as if atrophied, narrower, very irregular, and distant from each other, for ten of them occupied, at different points, a space of from 3 to 11 millimeters."

However this may be, the gymnotus is, then, according to what precedes, provided with highly developed electric organs. Nervous branches, proceeding directly from the spinal marrow, ramify, as in the ray, on the posterior face of the plates or diaphragms.

The Electric Silurus.—In the silurus the electric apparatus consists of two flattened sacs under the skin and separated from the rest of the body by a layer of fat. These sacs almost completely envelop the animal, with the exception of the extremity of the nose and of the different fins. The cavity of the sacks is partitioned off into little cells, which are pressed against each other and contain, each of them, a vertical disk one of whose faces is posterior and the other anterior. These plates have been particularly well studied by Bilharz and Max Schulze. They were not recognized by Saint-Hilaire and Pacini, who, however, gave an exact description of the electric apparatus as a whole. The nerves are furnished by a large trunk which has its origin between the spinal nerves of the second and third pair of an enormous ganglionary cell. This nerve, which is made up of a single primitive fiber of large size, ramifies in the electric organ and enters the electric plates through their anterior face, and not through their posterior one, as in the ray and gymnotus. This anatomical fact, as we shall see further along, is of great importance.

We shall speak but briefly of the organs of the mormyrus and gymnarchus, for their electric power has not been experimented upon. In the first there are two pairs of organs, quite like those of the ray, which are placed longitudinally upon the sides of the tail. Each of these organs, according to Koelliker, consists, in *Mormyrus longipennis*, of a series of from 140 to 150 very thick diaphragms, placed vertically. As for the gymnarchus of the Nile, named by the Arabs *Abu-Rad* (Father of Lightning), it is formed, according to Erdl, of four pairs of ordinarily arranged parallel with the vertebral column and unequal in length. These chaplets are formed of small prismatic bodies to the number of 136 in the larger series, extending from the second dorsal vertebra to the extremity of the tail, and of 5 only in the shorter one, which, situated above the others, rests immediately beneath the muscles of the fin-rays.

In some, the electric organs of all fishes consist essentially of columns or series of disks or electric plates, whose position and direction vary with the species in such a way that these plates have in the torpedo an upper face and a lower one, this latter receiving the extremity of the nerves, and in the other electric fishes an anterior face and a posterior one, this latter being the seat of the nervous terminations, save in the silurus, where the nerve penetrates through the anterior face.—*H. Beauregard, in La Lumiere Electrique.*

POSTAL BOX.

Our illustrations show a cheap and efficient style of box in use in Germany. It consists simply of two pieces of
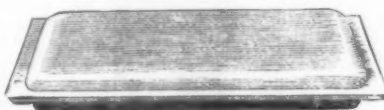
POSTAL BOX, CLOSED.
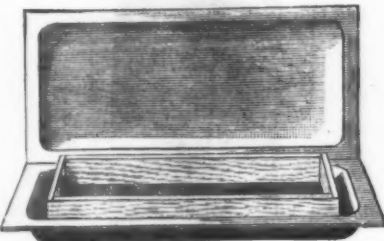
POSTAL BOX, OPEN.

card board, each moulded, by immersion in hot water, into a dish-like form, and strengthened in the interior by four strips of wood fastened together so as to form a loose frame. The plant is placed within the loose frame, and the shallow dish-like boards form the covers, which are kept in place by string.

MODE OF LOCALIZING BULLETS.

In the *Transactions* of the Vt. Med. Soc., Dr. S. J. Allen says:

"During the four years of the war I served in the field one year as Surgeon of a regiment, two years as Surgeon-in-Chief of a division, and the last year as Medical Inspector of the Sixth Corps, and must have seen and examined, if not treated, many gun-shot wounds. In all I have examined, be they more or less in number, I never localized a dozen bullets with a probe.

"In nearly all not localized by the finger, or sense of touch, I succeeded in fixing with certainty their exact location by the use of the exploring needle.

"I claim that if the bullet did not enter either of the cavities of the body, but lies anywhere in the periphery among the muscles, or other tissues exterior to them, the exploring needle, in the hands of the surgeon, will, by puncturing a reasonable number of times, hit the ball, and convey the intelligence of its exact location.

"Had the exploring needle been used in the case of our late President, the 'encysted wad of puss in the right iliac region' would have been punctured without appreciable resistance, and his surgeon saved the Blissful diagnostic error contained in several of their bulletins, which located the fatal bullet at that exact point with absolute certainty.

"A serviceable instrument for this purpose will be found in the smallest sized exploring needle, with which, all will admit, it is quite safe and comparatively painless to make the puncture.

"It is not unusual to puncture not only the peritoneal cavity, the pleural cavity, and the bladder, but the intestines and the pericardium; and seldom has harm resulted.

"The probe should be used only to determine the direction the ball took from its point of entrance, and to ascertain if it entered a cavity. Here, I claim, its usefulness ends, and if further used does harm.

"The surgeon almost always has an impression, after an examination, that the ball lies at a certain point. To test this impression, push the exploring needle from the surface directly down to this point. If it does not hit the resisting bullet, try at the next most likely point. If not successful, try again. The bullet can be localized in this way many times where all other methods fail. When the needle hits the ball, the surgeon will make the counter incision for its extraction with perfect confidence.

"Supposing that the bullet lies in close proximity to a bone, or is flattened upon a bone, by using a little more force the point of the needle will be made to penetrate the ball slightly, and will stick a little, and thus convey to the surgeon's hand a sensible difference between bone and lead."

TABLE OF CONTENTS.